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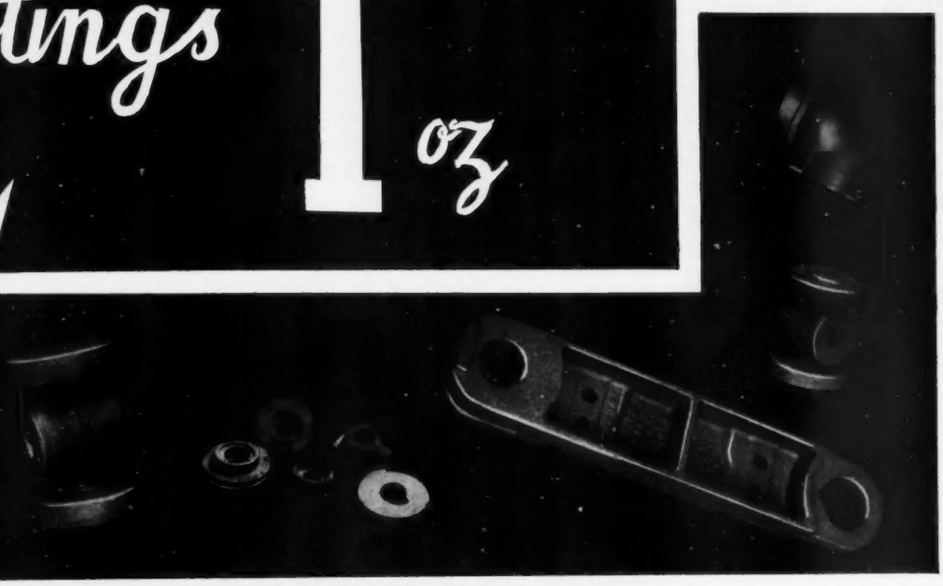

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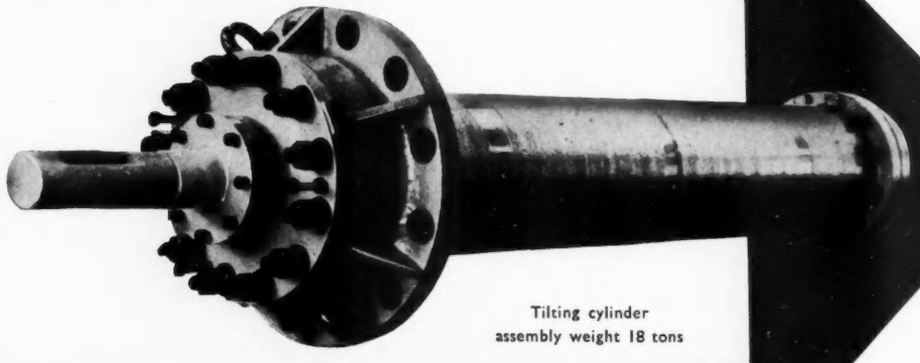

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ENGINEERING

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PUBLISHED EVERY FRIDAY

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ENGINEERING *Appointments Section faces page 96*

Starting from Here

THE mood of disillusion that has beset the atomic energy business for over a year shows signs of passing. Yet at a time when recovery seems imminent, criticism of the industry has gathered force and threatens to depress rather than encourage its revival. A vote of confidence is likely to be more rewarding in the present circumstances. But have we reason to feel confident? The answer may be discovered in the logic of our situation and the pattern of our evolution in the application of atomic energy.

There is a paradox in Britain's nuclear development. The feature that fundamentally distinguishes a nuclear reactor from other power sources is its virtual independence of fuel supplies: a single charge of uranium may last a year or more. At first sight therefore the most promising application of nuclear power would seem to be in remote and isolated territories where other fuels are not readily accessible. But in such places power demands are not likely to be substantial, and a small reactor would be sufficient to meet the overall requirement of any conceivable industrial oasis.

Britain's present reactors are big, ranging in output from several score to several hundred megawatts. They have been built, not because uranium is easily transported, but because uranium is an alternative to other fuels, which may fluctuate in cost or availability. The size of these reactors follows from the chain of circumstances that led to their development.

Like the United States, Britain first entered the nuclear field for military reasons. Nuclear weapons require virtually pure fissile material: either uranium 235 or plutonium. To separate uranium 235 from natural uranium involves a lengthy and expensive process, whereas it is cheaper and quicker to make plutonium in a nuclear reactor. Britain's first major reactors, at Windscale, were built to produce plutonium for atomic weapons. These reactors burn natural uranium, part of which is converted into plutonium, and for such reactors to operate at all they must necessarily be large. At the same time no great river, like the Savannah in America, was available to cool them, so air cooling was adopted. For these reasons, and because enriched uranium was still expensive, Britain's first power reactors were gas cooled and used natural uranium as fuel.

Here then is the essence of our dilemma. The future of the large reactor is limited, since comparatively few are needed to satisfy even an extensive power programme. And small reactors, which could lead to the development of many barren places throughout the world, require enriched fuel, which we are unable to supply.

But here too lies our strength. Plutonium as we have seen, can be produced more economically than enriched uranium, and our enormous power reactors will soon be, making copious quantities of this useful element. The United States, which has stockpiled enriched uranium for military purposes, can now afford to sell it cheaply; but eventually the economics of production will give plutonium the advantage. Even now the Americans are belatedly planning gas-cooled reactors, and negotiations are in progress for the construction of a further plutonium-production reactor. Also the United States is reported to have an arrangement with us whereby Britain will supply plutonium in exchange for enriched uranium.

These are encouraging signs. At present, small reactors are uneconomic to operate because the cost of the necessary enriched fuel is prohibitive. Once plutonium becomes available the situation may be radically changed. So far plutonium has only been used experimentally as enrichment, but there it little doubt that plutonium ceramics will eventually prove practicable fuels.

Britain's basic atomic policy has been sound. Unlike any other nation, Britain has the foundation for a self-sustaining complementary programme. Without the big reactors, economic small reactors might never become possible. Already several companies have submitted their designs for small reactors, which, though intended primarily for ship propulsion, are also likely to prove suitable for land-based application. The Select Committee on Estimates has recommended that the development of fast reactors be accelerated so as to reach fruition by 1966 instead of 1970. The fast reactor, for all its technical awkwardness, has been tipped as a promising runner in the plutonium-burning stakes. Be that as it may, in choosing a small reactor, the first criterion should be its potentialities as a plutonium burner, and if the chosen reactor proves unsuitable for marine propulsion, then we had best, in the interests of the power programme, prepare to abandon ship.

But the question is not simply to discover what the situation requires, but how to adapt our present evolutionary development to that situation. There is the story of a man who asked the way to such and such a place only to be told by a local countryman: "If I were going there, I wouldn't start from here." But, for better or worse, this is precisely where we are.

Cover Picture.—*The 12 ft diameter shell made from 1 in thick material that is shown in the cover picture is for an all-welded cement kiln. The picture shows a longitudinal butt-weld being made from an overhead travelling gantry.*

(*Nurnberg photograph for* ENGINEERING)

Plain Words

I saw a sad and sorry sight last week; at least so it seemed to me. It was at Newcastle, Co. Down, " where the mountains of Mourne sweep down to the sea." The railway station looked quite normal; it had all the outward appearance of a seaside railway terminus. Even inside, the bookstall was doing trade and people were moving about. But no ticket collectors stood at the barriers—because no trains come to Newcastle now. There used to be two tracks between the two platforms but they were ripped out several years ago. Grass and weeds flourish.

I know that railways all over the world lose money, and have done since the motor-car became a serious competitor. I know, too, that in Britain and possibly in other countries freight rates and passenger rates are regulated by statutory requirements in such a way that the railways are forever trying to catch up with rising costs and never quite succeeding. I am weary of the arguments for closing down the less important lines, because I think this policy of reducing the railways should not have been necessary. An opportunity was missed about thirty years ago; after the First World War, I would guess.

The railways had monopolised transport in the 19th century, so as passenger traffic grew they ran heavier and heavier trains. The chief mechanical engineers got great fun out of designing bigger and bigger locomotives, but if the passenger missed the 10 a.m. he had to wait for the 1 p.m. That was fine for the railways as long as they had the monopoly. When competition came from the motor-car there should have been some drastic re-thinking on the railways. There should have been a willingness to jettison accepted practices after a deep study of the developing situation. But there was no such willingness. The railway boards plodded blindly on.

In hankering after revitalised railways perhaps I am refusing to accept the inevitable. But I cannot help wondering how the railways would be faring today if in the 1920's the big named trains had been abolished and the passenger traffic taken over by hundreds of small—even single-car—trains. I cannot believe that busy men and women really want to drive themselves on the public highway, with all the mental and physical fatigue it involves.

But perhaps there was an even more fundamental mistake, made many years earlier. Was railway signalling—with all the elaboration with which we are familiar today—was it really necessary? Surely frequent light trains could have been run without signalling, except for some form of control at junctions?

CAPRICORN

Weekly Survey

Crying Out for Steel

In the second quarter of this year, according to provisional figures released by the Iron and Steel Board, the consumption of steel increased from a weekly average of 244,000 tons to 261,000 tons. This puts consumption back to about the same level as in the second quarter of 1958. The board says that consumers' and merchants' stocks were both run down at the same rate in the second quarter of the year as in the first quarter. Deliveries of steel to home users were higher and in consequence home consumption showed an increase.

The pattern of consumption has remained unchanged over the last few months. Deliveries to the motor industry are now 10 per cent above the level reached in the first quarter of 1958 and deliveries to hollow-ware, metal furniture and wire manufacturers, which can be taken as representing the consumer durable goods industries, are only slightly below previous peak levels. Building and constructional engineering, and to a lesser extent general engineering, have shown significant increases and exports have also improved. The most disappointing performance continues to be put up by the railways, coal mines and shipbuilding. In consequence, it is the sheet mills followed by mills making tinplate, strip, wire rods and ferroconcrete bars which have shown most resiliance of late, while deliveries of light sections and heavy rolled products remain sluggish.

Petrol Blended While You Wait

The development of high octane petrol for use in high compression engines has been one of the main changes in petroleum marketing since the war. In the United States the choice offered the motorist is much wider than here. The Sun Oil Company of Philadelphia has introduced a system of retailing which enables the motorist to choose the particular octane blend that he thinks most suitable for his car. The right mixture is delivered by means of a multi-grade pump which supplies six different grades ranging from 94 to 102 research octane petrol all from a single-hose nozzle.

The pumps works from two underground tanks, one containing the company's basic 94 octane premium brand, and the other a very high octane concentrate. The streams from both tanks are joined at the delivery nozzle of the pump through a hose within a hose. An adjustable dial is used to set various blending ratios while a computing device works out the price of the blend according to its octane content. The system was tried out in Florida three years ago and has now spread across the Atlantic to West Germany. BP Benzin and Petroleum AG have introduced a multi-grade pump manufactured by a German engineering firm. The pump not only dispenses both basic and premium grades in the ordinary way, but also delivers blends of the two in the proportions 75 : 25, 50 : 50 or 25 : 75. This means that five grades of BP are available from the one pump. Just how accurately drivers can work out the requirements of their particular engines is a matter for conjecture. But as a further step in the move to please the customer, the new blending arrangements will no doubt be very popular.

Aid for Indus Waters Plan

New hope has emerged that an international treaty settling the dispute between India and Pakistan, regarding the uses of the waters of the Indus River, may be negotiated during the early months of next year. Discussions which have been proceeding in London in the past few weeks between representatives of the two governments and Mr. W. B. Iliffe, vice-president of the International Bank of Reconstruction and Development, were so far advanced as to have been largely concerned with establishing the main heads of agreement for such a treaty.

It has been the aim of the World Bank to secure the adequate replacement of waters diverted from their existing uses in Pakistan, to provide a substantial element of development for both countries, and to discover means by which these objectives might be financed. The magnitude of the Indus problem and the issues involved were set out in an article " The Nile and the Indus " on page 750 of our issue of 5 December, 1958. Approaches have been made to a number of friendly governments, as a result of which it is confidently expected that financial assistance will be forthcoming, either in the form of grants or loans, from Britain, Australia, Canada, New Zealand, the United States and West Germany, in support of the loan which the bank itself will make. A keen desire has been shown by all these countries that the Indus dispute shall be settled, according to a statement by Mr. Iliffe.

The bank's plan will involve civil engineering construction estimated to cost some £350 million and to occupy at least ten years in building. More than 40 million people, almost one-tenth of the combined populations of India and Pakistan, derive their livelihoods either directly or indirectly from the waters of the Indus and its tributaries, and will benefit materially from the major increase in irrigation which will ensue from the successful implementation of the plan. Such a conclusion would also remove what is probably the most serious cause of friction that has developed between India and Pakistan.

Takeover Bids in Scotland

The use of the takeover bid to retain regional control of local industries was referred to by Sir James Hutchison, M.P., when speaking recently as chairman of Grampian Holdings Limited, a Glasgow finance company. Despite the takeover activities in recent years of the House of Fraser, which is nothing if not Scots, public opinion north of the border remains sensitive about English control of Scottish enterprises.

Monetary Measures

For the first time in 30 years a committee has reported on the operation of the monetary system in the City of London. But the Radcliffe Committee report published last week is not likely to be as controversial as the Macmillan Committee Report in its day. There are a large number of recommendations made throughout the Radcliffe Report, chief among which are that Bank rate changes should be announced in the name and on the authority of the Chancellor of the Exchequer and not by the Bank of England, that local authorities should finance themselves through the Public Works Loans Board and that a strong intelligence section should be developed in the Bank of England. The Bank of England's policy of part-time directors should be continued. The report is not dogmatic about the use of monetary controls as opposed to physical ones and it is therefore, in political terms, a middle-of-the-road document.

Two points from it are worth comment here. A notable feature of the report is its unanimity.

All members of the committee have signed it. This degree of agreement has been reached partly by leaving the meaning of words to individual interpretation. For example, the committee would be more inclined to favour physical controls as opposed to monetary ones in times of "emergency." An emergency means different things to different people. Second, and this point comes closest to the interests of the engineering industry, the committee is not in favour of variations in the degree of control of hire purchase as an instrument of monetary policy. It points out that the impact of such variations is felt disproportionately by the light engineering industries as against other industries.

Economies of Joint Research

Cooperation in research by the United Kingdom has led to large economies in money and manpower as well as guiding industry towards a better appreciation of the value of general research, according to the annual report for 1958 of the Industrial Grants Committee of the Department of Industrial and Scientific Research. The report of work carried out last year by the industrial research associations in the Government scheme was published at the beginning of June. The combined income of the research association of the DSIR last year was £6¼ million, and of this £4½ million was provided by United Kingdom companies and the rest by DSIR.

Power to Australia

According to a *Survey of Manufacturing Activity in Australia*, Australia has enjoyed a period of industrial expansion over the last year, marked by a switch in emphasis from consumer to capital goods. There has also been high productivity and lower unit costs following heavier investment in equipment throughout the Commonwealth. Prices have been falling and it would seem that Australia has passed through the same stage of the trade cycle in 1958-59 as this country is doing at the present time.

One of the consequences of development in Australia's capital equipment and basic industries is a boom in power development. This development is being concentrated increasingly on the coalfields. Over the 10 years to 1968 a total of £A1,318 million will be spent to more than double installed capacity. United Kingdom manufacturers of electrical and steam raising equipment have already begun to benefit from the boom. For example, English Electric has a contract for £A4·75 million for the first 200 MW steam turbo-alternators for the Vales Point power station in New South Wales and the Australian subsidiary of International Combustion is supplying boiler plant valued at £A7·5 million.

Colonial Development Changes

The long struggle to alter the financial structure of the Colonial Development Corporation has been taken a step further in a report of a committee of inquiry. The committee recommends that there should be an overhaul in the capital structure of the corporation. Members of the committee were Lord Sinclair of Cleeve (chairman), Sir Archibald Forbes and Sir Harold Howitt.

Controlling Energy Resources

It is not likely that the National Energy Board now set up in Canada will be able to start work before the winter, but the members of the board have been announced. The chairman is Mr. Ian McKinnon who has been chairman of Alberta's Oil and Gas Conservation Board, and who has been released by the Alberta Government for two years' federal service. The other four members of the board, who have been appointed for seven years, are engineers and economists.

Much of the board's work will be concerned with the export and import of oil and natural gas. Five applications for the export of natural gas to the US are awaiting its approval. The Act establishing the board lays down that all applications filed with the Government for export purposes will be automatically dealt with by a new procedure, involving hearings before the NEB, which decides whether each project should have a certificate. The first of five export applications is from Trans Canada Pipelines which is once again seeking permission to fulfill its contract with the Mid-Western Gas Transmission Corporation in the United States.

The membership of the board is heavily weighted in favour of experience in oil and natural gas, and this is perhaps understandable at the present time, since important decisions of policy and precedent have to be laid down about the export and import of oil and natural gas. For the time being, there is no atomic energy expert on the board and this omission has already attracted a certain amount of comment in Canada, a country which has been concerned with the development of atomic energy from the early days.

Cars Made in India

An automobile committee was set up recently by the Government of India to examine the progress made by the motor vehicle industry and to examine the possibility of making a low cost car. A certain amount of information is now available under the first of these headings. In 1953 an inquiry was made by the Tariff Commission into the industry and as a consequence only six factories concerned with the manufacture of motor vehicles, as distinguished from mere assembly, were allowed to continue in operation. A second inquiry was made in 1956 and tariff protection was granted for a 10 year period. The Tariff Commission estimated that by 1961 the annual demand for motor vehicles would be 65,000, including 40,000 commercial vehicles, 20,000 motor cars and 5,000 jeep type vehicles.

On a single shift basis the capacity of the six factories is now about 29,000 vehicles a year and total production is running at the rate of about 35,000 a year. Over the years 1951 to 1957, the industries ancillary to motor vehicle production have increased the value of their annual output from 15·8 million to 54·1 million rupees.

The UN Special Fund

An explanatory paper on the UN Special Fund was published by the United Nations in New York in January, 1959. A further explanatory memorandum has now been issued by the Export Services Branch of the Board of Trade, showing the type of project which the fund has been created to assist and the initial programme started this year. So far 13 schemes have been sponsored in countries including Latin America, West Africa, India, the Middle East, the Far East, and Europe including countries behind the Iron Curtain.

Call for Air Research

In the 22nd annual report of the Air Registration Board for the year ended 31 March, 1959, the chairman Lord Brabazon says that ways must be found to continue research and development if this country is to retain its position as a leading constructor of civil aircraft. He adds that since the cost of such basic research is high, it seems unlikely to the board that the burden can be borne only by constructors and their customers.

Letters to the Editor

SEAWORTHY REACTOR

SIR, We read with great interest the details in the articles by Captain H. F. Atkins, R.N., of his company's proposals for a marine reactor installation. All the schemes submitted to the Admiralty were clearly the result of a great deal of thought and design effort. Given varying amounts of money and time, it is probable that any one of the systems could be developed into an operationally reliable but not necessarily economic, marine propulsion unit.

A number of criticisms were made by Captain Atkins of the rival systems; we feel qualified to comment only on those which concern our own marine proposal:

(1) Of the seven designs submitted, only two, the high-temperature gas-cooled proposal and our own—both graphite-moderated and gas-cooled—were sufficiently small to fit under the lower deck above the reactor compartment.

(2) We feel that a conventional steel pressure vessel operating at moderate pressures and containing a non-corrosive atmosphere has advantages from the safety point of view when compared with certain other (notably callandria) systems.

(3) Using only graphite, carbon dioxide and steel in the primary circuit, compatibility problems are relatively trivial and well defined. Such problems as there are have already been very thoroughly explored.

We find it difficult to credit the claim put forward by Captain Atkins that his is "the only original and true blue marine design." A comprehensive feasibility study of the steam-cooled heavy-water-moderated system (SWR) was carried out by an American group of companies in 1957-58 and fully reported in August, 1958. (NDA-2562-1, *Steam Cooled Reactor Feasibility Study*, volumes I and II. See also the letter on "Steam Cooled Reactors" on page 2 of your issue of 7 August last.)

Our brainchild is directly descended from the first plutonium piles, from Calder Hall and Chapel Cross, and from the large civil reactors. Not a great naval family perhaps, but one with a fine tradition of its own.

Yours faithfully,
K. J. WOOTTON,
Manager, Atomic Energy Division.
General Electric Company Limited,
Erith, Kent.
20 August, 1959.

SIRS, I was very interested to read the articles on the steam-cooled heavy-water moderated reactor by Captain H. F. Atkins. I should, however, like to take up one or two of the points which have been made.

Ship reactor requirements are defined as reliability, flexibility, economic competitiveness, and independence of the United States. It is not clear why the steam-cooled heavy water-moderated helium-insulated indirect-cycle reactor qualifies particularly on any of these points. The system is undoubtedly complicated and involves novel circulating and control schemes, while heavy water and helium are difficult to obtain in this country. The 1·7 per cent uranium 235 enrichment required is not significantly less than in some of the competing systems.

The pressurised water reactor has an established marine technology abroad and cannot be dismissed in three sentences, despite possible limitations to its use. Similarly the boiling-water reactor justifies more consideration than is given. Blowdown of the reactor water is not necessary with the boiling-water reactor, as impurity removal is carried out by a bypass demineralising loop. In fact, the problem of water purity control in the PWR, BWR and steam cooled reactor is of similar magnitude, as indicated by the need for double distilled demineralised make-up water for the steam-cooled reactor. The latter reactor will have a leakage specification on the heavy water and helium circuits unprecedented in marine practice.

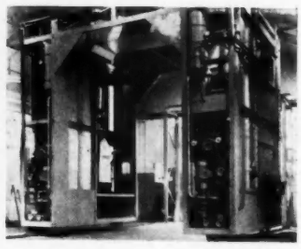
The stability of the boiling-water reactor is

SPRAY BOOTH
Rail Mounted Self-Propelled

A RAIL mounted self-propelled paint spray booth is now available designed for use in railway or bus paint shops where there may be a long line of vehicles.

The booth straddles the vehicle and the suction fans draw in air so that paint fumes do not escape into the open shop; fumes are discharged into a duct at roof level after passing through a washer. Water for the washer is contained in tanks mounted on the booth so that the only external supplies are the electricity for driving the fans, pumps and spray compressors. The booth is moved by hydraulic motors at any speed up to 25 ft per minute.

The operators stand on two platforms, one on each side, which can be raised or lowered independently by compressed air. Each platform also has an extension section that can be lowered to enable the operator to reach the centre of the open space; when these platforms are down, an interlock prevents the booth from being traversed. The working heights



are under the control of the operators but the traverse can only be controlled from one side. Explosion-proof fluorescent lights provide illumination for the interior.

Compressed air for both the spray and the platform mechanism is supplied by two 10 h.p. compressors of the two cylinder single stage type; air transformers on each platform give the pressure adjustment for the guns. A completely automatic fire extinguishing system is installed which stops all motors and releases carbon dioxide to blanket the spraying area. *Aerograph-DeVilbis Company Limited, 47 Holborn Viaduct London, EC1.*

RADIATION DETECTOR
Site Checks on Liquids

A PORTABLE electronic radiation detector has been developed primarily for recording the movement of radio-isotope bearing water in underground oil reservoirs. It can equally be used as a warning device for contamination of drinking supplies.

The instrument weighs less than 20 lb complete with batteries. It consists of two cylinders, the upper containing the transistorised voltage supply and the output circuits, and the lower one being the bypass through which the fluid being monitored passes and into which projects the detector tube. Separately mounted on the pole is the recorder with the integrating circuit and the batteries.

In order to keep down cost, commercial equipment has been used as far as possible, with perhaps some loss of efficiency. The battery supplying the vibrator and the high voltage supply has a useful life of 300 hours only, but the

five mercury batteries that supply the rest of the equipment will last for at least 1,000 hours.

The unit is designed for monitoring liquids at flowing pressures up to 200 lb per sq. in and is capable of detecting concentrations of 0·1 microcurie per litre of iodine 131; this gives a counting rate of 200 c.p.m. above background, while the normal background counting rate of the detector tubes is about 300 c.p.m.

A circular chart recorder has been used for economy since it has to be driven by clockwork. The whole equipment is said to be completely weatherproof. *US Bureau of Mines, Petroleum Experiment Station, P.O. Box 1321, Bartlesville, Oklahoma, USA.*

Continuing Letters to the Editor

now well understood. There are three principal design problems: they concern the interaction of steam generation with reactivity, the hydrodynamic stability of the flow circulation and the critical heat flux leading to burn out. Numerous experiments in both boiling-water reactors and experimental loops have established the design limits on these quantities in sufficient detail to enable safe and stable boiling-water reactors to be built. The effect of roll and vertical acceleration on the core performance is understood and can be accommodated in the core design. Some increase in the static condition design margins is necessary, particularly for a natural circulation design. In the pressurised BWR, reactivity is essentially independent of the depth of water above the top reflector.

The advisability of using organic liquid for moderator as well as for coolant is a subject of discussion in reactor circles. However, there is at present more extensive experimental information on reactors cooled by organics than by steam. Captain Atkins's intuitive approach to the behaviour of organic, and other, aspects of reactor design, must be checked in detail with experimental evidence. In the recently published marine proposals, the organic reactor required less enrichment than the steam-cooled heavy-water moderated reactor: at any rate, it is fair to say that the enrichment is comparable in both systems.

The use of a direct-cycle gas-turbine system is some way off, but its signal dismissal on the grounds of turbine limitations is surprising in view of British companies' success in this field. The leakage of fission products from fuel elements into the coolant would be at least as severe with steam cooling as with helium cooling and, in the former case, induced activity would also be present. It must be assumed, therefore, that some of Captain Atkins's doubts on gas cooling do not preclude the coolant gas being steam!

Nuclear power is today a practical proposition on land and sea. The reactor designer's task is to make it economic by reducing both the capital and the fuel costs. The main advantage of using heavy water as a moderator is to reduce the latter. The parameters for the steam-cooled heavy-water moderated reactor given in Captain Atkins's first article show a mean core life at full power of 5,500 MW days per tonne UO_2, using an initial enrichment of 1·7 per cent uranium 235. However, his second article suggests there may be some limitation on this from the control scheme in the present design. This irradiation life is low compared with BWR (about 10,000 MWD per tonne), and will lead to high fuel costs (pence per shaft horsepower hour) compared with BWR unless fabrication and processing costs are considerably lower than has hitherto been found possible in the United States (about $130 per kg of uranium). In addition, the make-up costs of the heavy water and helium must be considered if losses exceed much more than a few pounds per day of either in a 150 thermal MW plant.

As the complication of the steam-cooled heavy-water-moderated helium-insulated indirect-cycle system tends to make its capital cost high compared with the boiling-water reactor, the superiority in overall economy of the system is not apparent. The main advantage for this reactor system would be in operation with natural uranium. At present, it is believed that fairly large land plants moderated with heavy water and cooled by organic, light water or steam might just meet this goal. It is probably with an eye to future land practice that it is most important that experience should be gained in this country with the pressure-tube type of reactor. The construction of the pressure tubes and associated components which, in large numbers, make up the most critical parts of the core needs to be developed and proved very thoroughly before it can be used in a reactor. It would be most unwise to build our first pressure-tube reactor in a ship. The claim that the steam-cooled heavy-water-moderated reactor was specially conceived for marine use can hardly be treated seriously.

The steam and helium and control connections make the top and bottom of the core extremely complicated in this system. This is indicated in the diagrams published in ENGINEERING. Control by moderator quantity is theoretically satisfactory, though relatively untried and the dependence on gravity for the operation of both control and scram under all angles of list and conditions of ship motion must be carefully considered.

Dissolved solids in the feed water to the once-through boiler will either be deposited in the boiler or carried into and through the reactor where they will become activated, before becoming redissolved in the condensing boiler. To counter this tendency for activity to build up in the primary circuit an ion exchange polishing unit is provided to clean up the primary circuit. It is thus seen that the problem of water purity control is very similar to that in the PWR and BWR.

The pressure and temperature of the steam in the reactor will be closely tied to the behaviour of the feed pump, thermocompressors, heavy-water control valves, and the general nuclear behaviour of the reactor. It will surely be necessary to test the control scheme in a land based prototype to prove reliability and flexibility.

It is important that as soon as possible Britain should obtain sea-going experience with a prototype of a reactor which is likely to become economic. This does not preclude us from making full use of American developments in this field, if this saves time and expense, provided the future is secured by instigating research and development at the same time. The Royal Navy has not considered it wrong to purchase their first submarine reactor, lock, stock and barrel from the United States. The BWR and PWR could, with some assistance from the United States, be built into a British ship immediately. The tendency is to allow boiling in the PWR, which is, therefore, developing in the direction of the BWR. The latter, offering the chance of a direct cycle is already within striking distance of being economic. Extensive experience of the direct cycle BWR has shown this reactor to be highly reliable for the following reasons:—

(*a*) The core is accessible and of simple design.
(*b*) The remainder of the circuit is simple and uses conventional plant items.
(*c*) The reactor has a negative power reactivity coefficient which makes the reactor easy and safe to control, either manually or automatically.
(*d*) The primary circuit is easily maintained because the evaporative process retains long lived activity within the reactor.
(*e*) Considerable development work has been completed on reactor components.

The BWR is extremely flexible due to:—

(*a*) The ability to absorb reactivity in voidage almost instantaneously means that rapid load changes can be made (10 per cent to 100 per cent in less than one minute).
(*b*) There is no appreciable temperature change in metal components of the reactor on changing load.
(*c*) Considerable scope is available on a given reactor for altering fuel cycles, refuelling intervals, and enrichment material (uranium 235 or plutonium).

Yours faithfully,
P. C. DANNATT,
Engineering Department.
EAI—John Thompson Nuclear Energy Company Limited,
Radbroke Hall, Knutsford, Cheshire.
20 August, 1959.

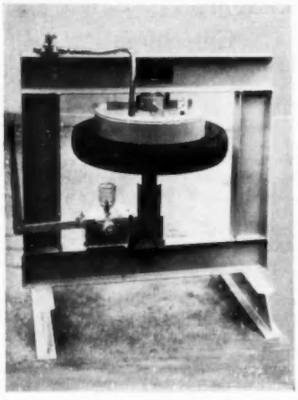
INFLATOR

Designed for Tubeless Tyres

A HAND operated machine for inflating tubeless tyres is now available, which will complete the action in 30 seconds.

A wheel with the tyre and valve already assembled is placed on the lower platen of the machine with the rim above the annular rubber ring of the platen so that air will not leak when the supply is turned on. The lower platen is then raised by the hand jack until the wheel makes contact with the top platen, where it meets a rubber seal. When firm contact is made the outer ring of the top platen will have depressed the upper side wall of the tyre leaving a gap between the bead and the rim through which air can enter. The jack is then locked by an isolator valve.

Air is then admitted to the upper platen and fills the tyre to close the gap. At 15 lb per sq. in above the required value the air is cut off. The pressure in the tyre forces the lower platen downwards and the tyre bead snaps back into place thus completing the seal.



Standard machines operate from works air lines at 70 to 100 lb per sq. in and have a safety valve to prevent over inflation. Platens will accommodate 13 in, 14 in and 15 in wheels; platen changing takes less than 5 minutes. *Hymatic Engineering Company Limited, Glover Street, Redditch, Worcs.*

BENCH DRILL

High Speed Sensitive Model for Light Work

RECENTLY reintroduced is the model 816 high speed sensitive bench drill which has a capacity of up to $\frac{3}{16}$ in in mild steel.

There are three spindle speeds, 1,400, 3,000 and 6,000 r.p.m. with the motor running at 2,850 r.p.m. The speeds are obtained by belt and cone pulleys. The spindle feed has a travel of $1\frac{1}{4}$ in and is fitted with a depth stop graduated in sixteenths. A micrometer attachment enables the stop to be adjusted to within fine limits. The spindle pulley is fixed to a sleeve mounted on ball bearings and arranged to relieve the drill spindle of all belt strain. An oiler is fitted to the front of the head for lubricating the spindle pulley bearings. The driving motor is rated at $\frac{1}{4}$ h.p.

The worktable measures 8 in by 5 in and has a vertical movement of $1\frac{1}{2}$ in. The maximum distance from the chuck nose to the table is 6 in. From spindle nose to column face there is $4\frac{1}{8}$ in. The sensitivity of the feed is obtained by a balanced lever control and enhanced by

having cushion springs fitted on each side of the drill spindle. Overall, the machine measures $22\frac{1}{4}$ in high and it weighs $\frac{3}{4}$ cwt. The standard model is supplied with built-in lighting, drill chuck and motor for three phase 50 cycle supply. *A. A. Jones and Shipman Limited, Narborough Road South, Leicester.*

STACKER

Operated by Propane Gas

ADDITION to the range of Brimpex stackers is a model that is powered by propane gas.

Advantages claimed are that it can be operated without heavy batteries or trailing flex and the gas engine gives almost complete combustion, avoiding the usual emission of obnoxious fumes which often renders internal combustion engines undesirable in confined spaces.

Other claims include cheapness of operation; in a sustained test the machine lifted an aggregate of 60 tons in one hour at a cost of approximately 8*d*. Economy is achieved by linking the throttle lever to the lifting control lever so that the throttle is only opened during the actual lifting period; the engine reverts to tickover during lowering and waiting times. Gas is supplied from standard 10 lb Bottogas containers which can be easily changed.

The lifting capacity of the range of trucks is up to 7 cwt at a rate of 40 ft per minute; heights of lift are 5 or 7 ft.

Industrial Machine and Equipment Company (Brimpex) Limited, Brimpex Works, Yorktown Industrial Estate, Camberley, Surrey.

TIME CALIBRATOR

Push Button Selection of Intervals

THE type CU3A unit is a time calibrator device designed for convenience and compactness.

The time intervals, which range from 0·5 microsecond to 1 millisecond, are selected by means of push-button switches. Each switch remains depressed until a "cancel" button is operated, thus a mixed output of markers may be obtained. The markers mix additively so as to facilitate counting. Both positive and negative going outputs are available and at the same time one or more individual time markers may be derived from sockets on the panel.

The marker accuracy is checked against an internal 2 Mc/s crystal. Markers may be free-running or keyed from a square wave source. Apart from the free running mode, it is also possible to operate the unit with an external keying source, with an internal source synchronised to an external wave form, or with external apparatus triggered by or synchronised to the internal keying source. For example, when checking the calibration

of an oscilloscope time base, a square wave derived from the time base could be used to key the time calibrator and a stable display would be obtained regardless of any alterations in the oscilloscope control settings. *Cawkell Research and Electronics Limited, Scotts Road, Southall, Middlesex.*

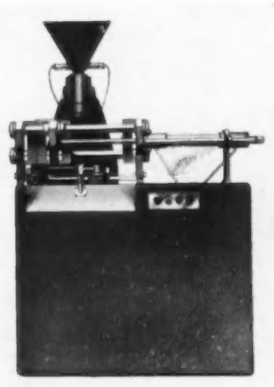
BLOW MOULDER

Automatic Machine for Plastics Containers

A FULLY automatic machine for producing plastics containers combines an extrusion press with a blow moulding section. Production rates of the Blowmaster are up to 600 articles per hour in sizes up to 6 in high and $3\frac{1}{2}$ in diameter.

A central moving platen carries a half mould on each face and moves between two stationary platens carrying the other mould halves. Mounted above is the extrusion head from which a length of tube is formed. As the platen moves across, it cuts off this tube length and carries it to one of the stationary moulds. Compressed air at 60 lb per sq. in is forced into the tube expanding it to fill the mould shape. In the meantime, a second length of tube is being extruded, and the platen on its return movement cuts this off in turn and takes it to the second mould where the expanding process is repeated.

The length of tube extruded for each operation is controlled by a photo cell and the timing of the platen traverse



can be adjusted. The extrusion barrel is heated in three zones with a rating of 6kW. Motors of 5 and 4 h.p. respectively drive the extrusion screw and the platen travel. *Amigo Machine Company Limited, 16 Gorst Road, London, NW10.*

HARDNESS TESTER

Air Operated Unit

IN the Olsen Air-O-Brinell hardness testing machine the load is applied by compressed air.

It is claimed that the machine combines the compactness and accuracy of hand operated types with the operating ease of motor driven models. There are no mechanical linkages, deadweights or hydraulic circuits; accurately regulated air pressure is applied by a diaphragm to the ram which carries a hardened steel ball that in turn applies the selected Brinell load to the specimen. On closing the load valve the ram retracts automatically. Under normal operating conditions 1·2 cu. ft of delivered air is needed for each application, the minimum working pressure being 65 lb per sq. in. Pressures above this have no effect on the accuracy of the machine. The load is pre-selected by setting the pressure on an air gauge, after which any number of tests can be made in succession at the same pressure. *Edward G. Herbert Limited, Atlas Works, Levenshulme, Manchester 19.*

DITCHER

Cuts 22 ft Wide Canals

THE Gar Wood-Buckeye ditcher illustrated will cut trapezoidal irrigation canals up to 22 ft wide, or straight ditches up to 5½ ft wide and 11 ft deep.

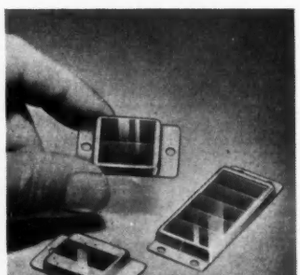
The machine is at work in Cameron County for the Texas Water Board. After the levee is built the ditcher starts work with an average speed of 7 ft per minute and an excavation rate of 800 cu. yd per hour. When digging a straight-sided ditch it has achieved speeds of 35 ft per minute in operation. It can be modified for use as a ditcher for pipe-line work and can be adjusted for cutting canals of varying widths and depths. The digging buckets on the main wheel and the rotary side cutters can be changed to suit the job specifications. The depth of cut is controlled by the digging wheel which is hydraulically raised or lowered.

Spoil can be discharged from either side of the machine or from both sides at once—an obvious advantage when building banks to the right height. Discharged spoil can afterwards be compacted, in this case to form a service road running along the side of the canal.

A concrete boat or slip form is attached to the ditcher by a cable so that if the ditcher is running and concrete is being placed the ditcher pulls the slip form at its own speed. If the ditcher is not running the slip form can be pulled up to it by the winch or the third possibility is that the ditcher can move ahead and pay out the cable behind it, the slip remaining still. It is said that the Allison Torquematic three speed transmission gives very smooth operation. *Mackay Industrial Equipment Limited, Faggs Road, Feltham, Middlesex.*

SOLAR CELLS

Electricity from the Sun



SILICON solar cells are now available with conversion efficiencies of up to 10 per cent. A typical installation of cells arranged in series-parallel will charge a 12 volt nickel-cadmium battery at 1A.

Unmounted cells in commercial grades measure from 1 cm by ½ cm to 1 cm by 2 cm. With a conversion efficiency of 8 per cent the largest size will give an output of 14 mW with an operating voltage of 0·4V and a current of 35 mA approximately. They can be supplied with pigtail leads if desired. The figures quoted are for incident light of 100 mW per sq. cm with the cell temperature at 30° C. The response is peaked in the short infra-red range making the cells suitable for infra red detection. Output power falls off with increasing temperature. A calibration curve, showing the efficiency of the unit at various radiation intensities and recommended temperature conditions, is given with each cell.

The cells can also be supplied in mounts as building modules and are so shown in the illustration. A bank of five connected in series measures 0·89 in by 2·44 in overall and has an output of up to 70 mW at 1·75 V. The cells are embedded in epoxy resin which is said to form a shock proof rugged housing, proof against weather. Insulated soldering terminals extend from the bottom of the module case. Banks of sufficient numbers of these cells are able to give powers ranging up to several hundred watts. *International Rectifier Company Limited, Hurst Green, Oxted, Surrey.*

ARMATURE TESTER

Detects and Locates Faults

THE Disa Armascope is an instrument for rapidly and accurately locating all faults that may occur in commutator armatures of small electric motors. There is only one operating control.

The armature to be tested is made to rotate in the field of a permanent magnet which has a field component at right angles to the axis of the armature. As the armature rotates voltages will be induced in the coils and these are taken off two adjacent segments and displayed on a cathode ray oscilloscope. If the armature is correct a regular pulse train will be seen on the screen. If the armature is defective the pulses will be of different heights or of opposite polarity.

Operating the lever to the right of the front panel will connect a pickup coil that is so positioned as to be affected only by those changes of flux that are caused by the passage of a shorted turn through the primary field. In this measurement for an armature with no shorted turns the oscilloscope will show a slightly wavy line; when there are shorted turns the pattern will show a distinct pulse. The position of the faults is located by a scale on the oscilloscope and a corresponding scale on the spindle. Armatures up to 75 mm dia. can be accommodated. *B and K Laboratories Limited, 4 Tilney Street, Park Lane, London, W1.*

EARTH TESTER

Current follows Fault Path

THE Megger line earth loop tester passes a current of 20A at full mains potential along the actual path of a fault current. That is, the circuit consists of the live conductor, the earth continuity conductor and the earth return path.

Since the test current is of short duration a ballistic meter is used. A synchronous motor energised by a push button switch drives a contactor which connects a 10 ohm resistor from the live conductor to earth for a period of 5 cycles. The current flowing will depend on the resistor plus the actual resistance of the path. The meter is connected in parallel with the resistor and can therefore be calibrated directly to read the path resistance. The motor is automatically switched off after the current has passed. Facilities are provided for resetting the pointer of the ballistic meter after the test has been completed.

Since the current flowing will also depend on the actual value of the mains potential, a voltage selector has been included so that instruments can be adjusted to the voltage of the local supply. An auxiliary voltmeter can be built into the instrument to give the exact value. Additionally, there is an indicator which has been provided to check the polarity of a three pin socket. The indicator lights when the polarity is correct.

The instrument can also be used for determining the actual earthing efficiency of an appliance. For this, jack plugs are fitted that modify the circuit to connect the metal frame of the appliance and the mains lead. *Evershed and Vignoles Limited, Acton Lane Works, Chiswick, London, W4.*

NANOSCOPE

For Observing Very Fast Wave Forms

THE Nanoscope is an auxiliary unit which when connected to an oscilloscope permits the observation of very fast repetitive wave forms of the order of a few nanoseconds (10^{-9} second) duration.

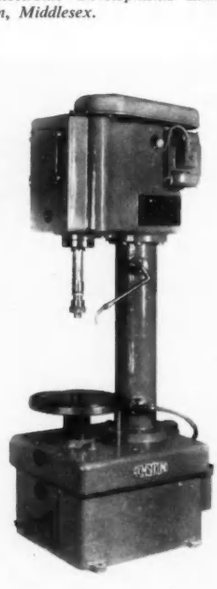
It operates by sampling the fast wave form with very narrow pulses at a number of points. This results in a series of pulses stretched to render them visible on a normal oscilloscope of restricted bandwidth. These ordinate pulses are brightened at their peaks, thus tracing the fast waveform as a series of dots on the oscilloscope face. Recurrence frequencies between 100 c/s to 10 kc/s can be observed.

To centre the sample pulses on the screen, means are provided to delay the sampling pulse until the time-base sweeps have started and have reached the appropriate point for the display. Coarse and fine adjustments are provided for this purpose. The latter is a helical potentiometer with 1,000 divisions, the whole of the range being equal in delay to twice the time-base sweep. Since this can be set as low as 50 nanoseconds it follows that each division of the fine delay potentiometer corresponds to 0·1 nanosecond, enabling the instrument to measure very short intervals of time. The rise time is less than 3nS.

The equipment is provided with a probe which with range switches on the main unit gives four settings for input voltages from 0·5V to 30V. An internal square wave generator enables the amplitude of the waveform being examined to be checked to within 5 per cent. The unit has a very low noise level at input of about 5 mV (mostly residual hum) and sensitivity of 5 mV per trace width. It is designed to work from normal 200-240 V 50 cycle supplies. *Lion Electronic Developments Limited, Feltham, Middlesex.*

CYLINDER HONER

Accurate and Rigid



THE Armstrong honer is designed for continuous duty and is therefore simple and robust. There are two types: the one illustrated includes models which will hone bores up to 8 in diameter and has a stroke of 60 in; the second will handle bores up to 15 in diameter but has a stroke of only 36 in.

The head, carried on a circular column, is of box construction and all the gearing is totally enclosed. The 2 h.p. motor drives a vertical shaft by a V belt. This shaft carries a worm for the reciprocating motion and a pinion for the rotary drive. The vertical movement is adjustable through a door in the head and the ratio of rotation to reciprocation is two to one in the standard machine. There are three speeds.

The rise and fall of the table is 9 in and is hydraulically controlled from a pedal. Maximum travel is 7½ in and bore sizes are up to 3½ in diameter by 9 in long. *Payne Products International Limited, Lawrence Estate, Green Lane, Hounslow, Middlesex.*

THE BMC BABY CAR

Fast Four-Seater Costs less than £500

By Gordon Wilkins

The 10 in wheels help to ensure a low centre of gravity which contributes to the excellent road holding.

The new baby car which BMC will be selling with both Austin and Morris name plates is a remarkable exercise in compact construction. It provides comfortable seats for four adults, reasonable luggage space and room for a large selection of packages and addments in a car only 10 ft long. With a kerb weight of 1,260 lb Overhang at front and rear has been kept to a minimum (the wheelbase is 6 ft 8 in) and the track is only 8 in less than the overall width. Very small wheels of 10 in diameter are used, so that the wheel arches make little intrusion into the structure. Large boxes for oddments are built into the doors and others are formed by sheet metal joining the centre door pillars to the rear wheel arches.

The four-cylinder o.h.v. power unit, developed from the BMC A-type, but with a shorter stroke, is of conventional design, but is mounted transversely and drives the front wheels. The four-speed gears are mounted below it in a finned magnesium alloy casting which also forms the engine sump. The clutch housing is of aluminium. Austin A35 gears are used and a train of three gears transmits the drive from the clutch shaft to the first motion shaft of the gearbox. A further two take the drive from the gearbox third motion shaft to the differential, making five gears in mesh for top gear. Other universal joints on the drive shafts are the Rzeppa type. Inner joints are a simple Hooke type with the spiders carried in conical rubber bushes; a new design developed by Moulton Developments in collaboration with the British Motor Corporation. The radiator is mounted to the left of the engine and warm air is led away into the left front wheel box.

Engine dimensions are 62·9 by 68·8 mm (848 c.c.) and with a compression ratio of 8·3 : 1 it develops 34 b.h.p. nett at 5,500 r.p.m. with maximum torque of 44 lb-ft at 2,900 r.p.m. (128 lb per sq. in BMEP). Power unit, with radiator, clutch, gearbox, final drive and accessories, weighs 308 lb almost exactly the same as the untrimmed body hull. The engine mountings are stiff vertically, but flexible about the crankshaft axis. Movement in this plane is restrained by a short link above the clutch housing, and by the exhaust pipe, which is designed to act as a second link. Power unit, transmission and front suspension are mounted on a sub frame attached to the hull by eight bolts in rubber bushes. Another sub frame, similarly attached, carries the independent rear suspension which is by single trailing arms. The suspension units, developed by Moulton and made by Dunlop, consist of a thick rubber ring bonded to a fixed cup on the chassis, and an inner flanged plate on an arm connected by a ball joint to the suspension linkage. In the free state, the unit is approximately a truncated cone in shape, but with deflection the ring is deformed between inner and outer plates, and forms a light, quiet suspension element with progressive rate. Light telescopic dampers are used to supplement the self-damping effect of the rubber. Tyres of 5·20 section have been specially developed by Dunlop.

The hull represents a new approach to the problem of easy, rapid assembly. The main elements, roof, windscreen frame, front wings, side frames and rear panel, are flanged outwards and joined by wheel welding. Afterwards the welded flanges are covered by applied U-section strips. The drop-down rear panel which gives access to the luggage trunk acts as a platform for bulky loads, but there is no through access to the interior of the car as a fixed panel behind the rear seat is used to increase torsional stiffness which reaches 6,500 lb-ft per degree measured at the wheelbase.

The impression of space in the interior is increased by the flat floor and by eliminating the conventional instrument panel. There is a simple open parcel shelf below the windscreen, with a small instrument cluster in a circular housing at the centre.

PERFORMANCE SUMMARY

Road speeds at Maximum Power (5,500 r.p.m.)

Gear	Without passengers	With 2 up	With 4 up
Top	81·7	66·2	56·0
3rd	58·0	47·0	39·2
2nd	38·0	30·8	26·3
1st	22·5	21·3	15·8

Acceleration Through Gears

m.p.h.	Sec
0-30	7·57
0-40	12·65
0-50	18·07
0-60	28·97

Standing quarter mile: 24·15 sec.

Fuel Consumption at Steady Speeds

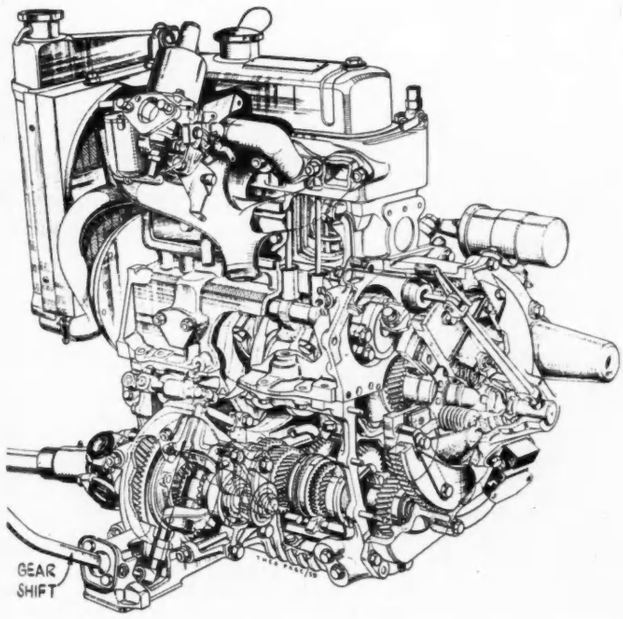
m.p.h.	30	40	50	60	Max.
m.p.g.	65·8	59·9	51·8	43·7	32·7

Braking Efficiency at 30 m.p.h.

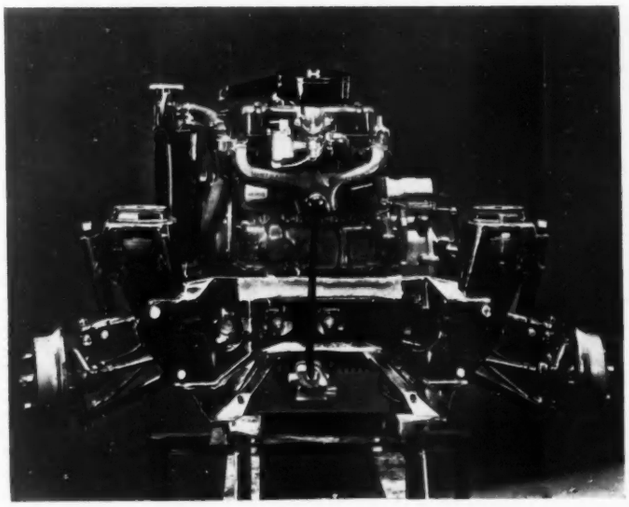
Pedal force (lb)	Retardation (per cent g)	Stopping distance (ft)
25	30	100
50	49	61·5
75	72	41·9

Turning Circle: 29 ft 6 in

	Basic price	Price with purchase tax
Standard model ..	£350	£496 19*s* 2*d*
de luxe model with heater and overiders ..	£378 10*s* 0*d*	£537 6*s* 8*d*



(*Left*) *The 850 c.c. engine, the gearbox and the final drive assembly form an integral unit weighing about 300 lb.*



(*Below*) *Looking from the rear, the compact design of the power unit and transmission can be clearly seen. One gallon of oil in the sump serves both engine and transmission.*

Airways and Airliners

The highway of the sky is to be introduced in Britain from 1 September, reserved exclusively for turbojet and turbopropeller airliners. It will run parallel to and five miles distant from the existing airway leading from London airport out to the North Atlantic. Decca Airway Amber One, as it is to be known, will greatly speed up the traffic at London Airport but it can only be used by aircraft equipped with the Decca system of air navigation and therefore not by the Boeing 707. The introduction of the new airway is intended as an experiment and its value will be reviewed at the end of six months. If successful it will be continued permanently and others introduced, particularly on the routes to the Continent.

A fleet of 24 Airco DH-121 medium range jet airliners costing some £30 million, has been ordered by British European Airways and a seventh Comet 4B added to the fleet of six already ordered. The order for the Airco DH-121 was placed with Aircraft Manufacturing Company Limited (de Havilland, Fairey Aviation and Hunting Aircraft), and deliveries will begin towards the end of 1963. Other good news for the industry has come from India, where Air India International may buy a small fleet of Comet 4 airliners and pool its resources with those of BOAC for the operation and maintenance of those aircraft. There is also a possibility that Qantas Empire Airways of Australia may re-equip with a few Comets. Orders for the Amrstrong Whitworth Argosy freightercoach aircraft may soon be placed by the Government for use on military duties. Some 20 aircraft are believed to be included in the first order but this may rise to 50 later.

Prescient Hoover

A large programme of expansion was outlined by the managing director of Hoover Limited, Mr. Sidney Roberts, when announcing his company's half-yearly figures recently. In addition to the £2 million scheme for the expansion of the Welsh factory group, considerable expenditure was foreshadowed at Perivale and Cambuslang in Scotland. Mr. Roberts described it as "a major investment programme in buildings, plant and equipment." All of it will be financed from the company's own resources.

The company's net profit before tax for the six months to 30 June amounted to £5·65 million compared with £2·11 million for the corresponding period in 1958. This resulted from an increase of some 90 per cent in overall sales to the home market, attributed partly to the removal of hire purchase restrictions last October followed by further reductions in purchase tax this year, and partly to the company's introduction of new models. All factories were therefore working to full capacity, making it possible "to obtain the benefit of economies associated with the increase in volume." Exports increased by 4 per cent. A word of warning, however: "on the home market there are signs that the demand is beginning to fall" and the advent of the Common Market is making Hoover's position on the Continent "much more difficult." It may well be that the current boom in the demand for electrical household appliances is coming to an end.

Mighty Europeans

The advent of the Common Market in Europe is already having its effect on the expansion policy of the major industrial units of the countries concerned. As Herr Alfred Krupp von Bohlen und Halbach pointed out in a recent speech about his own industrial empire, large markets need large firms to serve them: they justify a great concentration of resources. The national wish to have a stake in everything is less and the opportunities for Governments to support "key" enterprises correspondingly diminished. The risky business of investing very large sums in capacity, which must find an outlet beyond the political control of the country concerned has been replaced by relative security.

Pilgrim's Progress

Italy's Innocenti, manufacturers of seamless steel tube rolling mills, have embarked on a major expansion plan. They have recently supplied a complete rolling mill for the Costa Volpino works of Dalmine SpA and will supply a second similar mill to another of Dalmine's works in a few months. When fully in production these installations will produce "Pellegrino" (Italian for Pilgrim—the Continental term for the Pilger process) tubing of 60 to 175 mm diameter and continuous tubing of 53 to 92 mm at a rate of 150,000 tons per year.

Junkers Anniversary

Junkers recently celebrated the 40th anniversary of the first registration in the world of a four-seater all-metal cabin aircraft, the F-13, on 25 June 1919. It was covered with sheet metal, instead of being wire-braced as had been standard practice and was known as the iron aeroplane. Professor Hugo Junkers, the company's founder, celebrated his 100th birthday last February.

New Perkins Factory

The manufacture of a new range of outboard motors—made under licence by F. Perkins Limited from the Oliver Corporation of Chicago—is to be housed in a 140,000 sq. ft factory at Qalton, Peterborough, which was formerly used as a Royal Ordnance depot. United States equipment and machine tools arrived in June and production is expected to start in October.

Swedish Serenade

The two leading manufacturers of turbines in Sweden, Svenska Turbine AB Ljungstrom (STAL), a subsidiary of ASEA; and AB de Lavals Angturbin, have agreed to amalgamate "in order to meet the ever growing competition on the world market." Under the agreement, STAL will take over the Laval plant and change their name to Turbin AB de Laval Ljungstrom (TALL). De Laval will remain largely as a holding company and will obtain shares in TALL to the value of Kr 9,000,000 out of a total issued share capital of Kr 30 million. ASEA will also hold Kr 9 million, and the balance Kr 12 million will be offered for subscription to ASEA shareholders.

The merger should considerably strengthen Sweden's challenge in world markets for turbines, and there is every likelihood that Britain and the Commonwealth will be particular targets.

Engineering for the World

The progress of Head Wrightson and Company has continued during the 12 months to 31 January 1959 despite the recession. The company's chairman, Mr. Richard Miles, commented, however, that orders in the early part of the year were not being received at the required rate. Under the title "Engineering for World Industry," the company have published, in four languages, a most attractive—as well as informative—account of their work and products.

Compressor Factory

A new 78,200 sq. ft factory has been built at Hemel Hempstead by Allen Fairhead for Atlas Copco (Great Britain) Limited, representing "a continuation of the expansionary trend of the Atlas Copco world group over the last 86 years." Future expansion plans include an additional 130,000 sq. ft of factory space.

Record SBAC Show

It seems likely that the record number of 376 exhibitors at the 20th Society of British Aircraft Constructors' flying display and exhibition, Farnborough, September 7 to 13, will be matched by the largest-ever gathering of overseas guests. Quite a change from the first display at Hendon in 1932 when 21 member companies displayed their wares on trestle tables in two tents.

The classified section of the SBAC catalogue groups the many thousands of products under 150 headings. It would be impossible to deal with all of these here but mention can be made of Ferranti's airborne radar and fire control equipment (AIRPASS) on show for the first time. This equipment is fitted to the Lightning so that the pilot can find and destroy his target even if he can't see it.

The flying display will feature three important new airliners, a fighter and a trainer (both capable of exceeding Mach 2), a vertical take-off airliner, the latest marks of Great Britain's V-bombers, a wide range of helicopters, a "cushion-rider" and spectacular flying by the Royal Air Force and Royal Navy.

Aircraft Merger

Westland Aircraft have acquired the whole of the £648,000 issued share capital of Saunders-Roe, famous as builders of flying boats, who also make helicopters and other types of aircraft. The company have recently undertaken feasibility studies on atomic-powered submarine cargo vessels, as well as the building and development for the National Research and Development Corporation of the SRN-1 Hovercraft research vehicle.

Company Ownership

The second edition of *Who Owns Whom*, of which the first edition was reviewed in these columns on 1 August, 1958 (p. 152) and 8 August, 1958 (p. 171), has been considerably expanded and now appears in two volumes. Published by O. W. Roskill and Company (Reports) Limited, 14 Great College Street, SW1, volume one, priced at £4 4*s* 0*d*, follows the same layout as the previous edition but lists some 15,000 subsidiary or associated companies compared with 12,000 in 1958. For each of these the directory shows the name of the controlling or senior associate company together with a classification showing the principal industrial or trade interest of the latter.

Publication of the first edition in 1958 created a demand for a companion volume listing parent companies in alphabetical order and showing their subsidiaries. This demand is now met by the publication of volume two, price £3 3*s* 0*d*, if purchased separately, the two volumes together cost £6 6*s* 0*d*.

In addition to providing a quick and detailed reference to the size and structure of groups in the United Kingdom, volume two shows how far companies have moved away from their traditional field of operation by the acquisition of both public and private companies, and whether a company is interested mainly in subsidiaries making products similar or related to its own.

While it is understood that part of the increase of 25 per cent between 1958 and 1959 in the number of subsidiary and associated companies listed is due to the widening scope of the directory, the major part is accounted for by companies which became subsidiaries for the first time during the year. In addition the ownership of a number of companies changed hands during the year, a process which may be intensified if there should be a reaction in this country from the process of diversification as has already occurred in the United States. But there is no sign of a fall in the rate of acquisition of smaller by larger companies.

Space Engineers

Information on the results of several years' research into the problems of space flight will be given by the Hawker Siddeley Group at the Commonwealth Spaceflight Symposium which is being held in London at the end of the month. Two papers will be read by Hawker's engineers. One of these, by Dr. W. F. Hilton, will deal with a design for a revolutionary "upper atmosphere engine." Dr. Hilton, who has been working at Sir W. G. Armstrong Whitworth Aircraft on space research, is to head the astronautics section of Hawker Siddeley's advanced projects group. The other paper will be given by Mr. H. R. Watson, also of Armstrong Whitworth, dealing with the problems of re-entry into the earth's atmosphere, with particular reference to the re-entry of manned space vehicles.

Hawker Siddeley, who have financed all this research out of their own funds, appear determined to send us rocketing out of this world but in safety (and comfort). They are to reveal details of a possible design for a two-man space vehicle, believed to be aerodynamically sound which may well be just right for young couples emigrating to a near-by planet.

Aid for Amateur Scientists

Grants to help amateur scientists to pursue their interests are being given by the Carnegie United Kingdom Trust. The trust, which for many years had supported amateurs in music and drama, and since 1951 in the visual arts, made a grant of £9,000 last year to be used for the support of amateur scientists. This year the boundaries of their interest have been extended to include astronomy. Full details are contained in their 45th annual report published in June.

Option on Pensions

The National Insurance Act, 1959, which received the Royal Assent on 9 July, introduces into national insurance a measure of graduated contributions and retirement pensions related to employees' earnings. But it allows those in occupational pension schemes which satisfy certain conditions to contract out. The Minister of Pensions and National Insurance, Mr. John Boyd-Carpenter, has asked the National Insurance Committee to examine the first group of regulations published last week on the arrangements for contracting out.

The draft regulations, upon which the committee will receive representations up to 8 September, provide for the formal appointment of a registrar of non-participating employments who will decide applications for contracting out certificates. To allow time for consultation, employers intended to apply for a contracting-out certificate will be requested to give at least one month's notice to the employees concerned. Mr. John Boyd-Carpenter announced in the House that he had in mind to appoint as registrar Mr. N. Leach, at present under secretary in his Ministry, when the necessary regulations have been made.

More People in Work

Employment continued to increase during June, particularly in the manufacturing industries. The national total rose by 85,000 to 28·02 million but some of the largest increases reflect seasonal influences. The 24 per cent increase in the category drink, food and tobacco, is doubtless mainly attributable to recruitment by canning factories at the onset of the soft fruit season. Likewise a sharp rise in employment by hotels and catering establishments reflected the advent of the holiday season. Nonetheless, the improvement was general, except in coal mining, shipbuilding and shiprepairing. The engineering labour force rose by 5 per cent, that of the vehicle manufacturing industry and of the metal industries each by 2 per cent.

Unemployment at 13 July totalled 395,000 including 56,000 married women. There were reductions in most sectors, the largest being of the order of 5,000 in metal manufacture, and in shipbuilding and marine engineering.

Electricity University Scholarships

The electricity supply industry in England and Wales has awarded scholarships to schoolboys for university training. Under the scheme 45 candidates were given awards out of 350 applicants. It was open to sixth formers intending to read for degrees in science and engineering. Those successful are expected to to spend a short period of training with the industry before going up and to come back for two years after taking their degrees.

Morris Dance

The lightning strike of 350 paint shop workers at the Morris Motors factory at Cowley last week showed that all was far from well following the settlement of the dispute over the dismissed shop steward, Mr. Frank Horsman. The painters refused to work with a member of the Amalgamated Engineering Union who, they alleged, had done their job during the strike. Although the strike lasted less than 2 hours (the men resumed work pending negotiations) it suggests that the AEU's refusal to support the strike over the dismissal of Mr. Horsman has created a rift between them and the 11 other unions who withdrew their labour.

The AEU have made themselves unpopular, perhaps not so much because their 2,000 members remained at work, as because they are known to oppose the granting of too much power to shop stewards, and certainly not the power to call a strike. The situation is reminiscent of the trouble at Briggs Motors two years ago, when the shop stewards' committee had assumed most of the powers belonging to national union leadership. Another factor is the tough line taken by the management. Most motor manufacturers now appear fully prepared to face a prolonged stoppage rather than give way.

Memorial to Farm Tractors

A stone memorial cairn, topped by a replica of a Ferguson tractor, was erected by the townspeople of Wentworth, New South Wales, to commemorate "the epic fight" by the people of the district against the record flood of 1956 and "the major part played by Ferguson tractors and implements in saving the town from complete inundation."

Fewer Coalminers

The contraction of the coal industry is expected to continue, though perhaps at a slower pace than had been feared by the National Union of Mineworkers. The National Coal Board's revised plan for the industry was put before the unions at last week's meeting of the industry's consultative council. The plan was then considered at a special meeting of the NUM executive.

Unofficial reports suggest that the production target will be lowered from 240 million tons to about 200 million, which implies a further running down of the labour force and probably a reduction in the capital investment programme. Compulsory retirement at 65 may be a solution to the redundancy problem (nearly 15,000 miners are over that age) but the unions are expected to press very hard for a national fuel policy involving some restrictions on the use of fuels in competition with coal.

Electronics at Technical Colleges

Technical colleges have been notified by the Ministry of Education that courses of study in electronics leading to ONC standard in electrical engineering should contain more electronics if necessary at the expense of machines. Older syllabuses still reflect the predominant position of the power engineering of yesterday.

Aircraft Redundancy

The token 24-hour strike at the Chester Works of de Havilland and the more serious stoppage at Short Brothers are symptomatic of the anxiety which prevails in the aircraft industry. Leaders of the Confederation of Shipbuilding and Engineering Unions are expected to meet Mr. Aubrey Jones, Minister of Supply, some time next month, to discuss what the Government might do to alleviate the situation. Orders are being placed for new aircraft, but the unions—and in this case the employers also, are unlikely to consider that these orders will materially affect the situation. The fundamental question concerns the competitive ability of the British aircraft industry in world markets, where recently some ground has been lost to United States manufacturers. Despite a magnificent performance in the past decade nothing short of a miracle could prevent a substantial concentration of existing capacity.

That there must be redundancy is not seriously disputed by the unions. At Shorts, 6,000 are striking because about 1,200 men are to be sacked by the end of the year, but the context of Northern Ireland is a special one, with political issues not present in Great Britain. Workers at de Havilland are asking for better compensation terms. At Coventry 200 workers of Sir W. G. Armstrong Whitworth have been given notice. The inevitability of redundancy was recognised there also and no trouble is anticipated. The unions call for alternative work at the factories affected but this type of work is hard to find, and takes time to develop. The industry as a whole has not given itself time to diversify in a manner which would avoid redundancy.

African Surveyors

An all-African survey team is being used by the Uganda Electricity Board to carry out their extension programme. The survey section, consisting of six surveyors each in charge of 8 to 10 porters, have surveyed over 400 miles of line for different UEB projects since it was formed in 1957. Facilities are provided by the board to assist their surveyors in passing examinations leading to higher professional status.

Please Use Our College

The Council of the Industrial Association of Wales and Monmouthshire has asked industrialists to make more use of the Welsh College of Advanced Technology. They think that many students in 1958 were well qualified (on the Ordinary National Certificate results) to take a diploma in engineering but that few indeed did so. Employers have been asked to review their trainees' and apprentices' potentialities and consider sending them on for further study.

It also asks companies to provide more training places for college-based students. The plea is addressed particularly to other than large organisations which have often already offered as many places as possible. The Association has distributed a booklet called *Careers in Industry Index*, of its own compilation, to schools and youth employment officers.

INTERCONNECTED POWER SYSTEMS

More Links mean Greater Benefits for Europe

By J. H. M. SYKES

At present the utilisation factor of electric generating plant is somewhere about 40 per cent. Little can be done to alter the loading peaks in individual countries but, owing to the time differences that exist, peak demands do not occur in all countries at the same moment. Links between systems would allow transfer of energy on a large scale sufficient to enable plant, and in particular hydro stations, to operate continuously at or near their point of maximum efficiency. Such an arrangement would go far towards keeping down the cost of electricity.

The English layman who hears about the scheme to link British and French electricity supply networks with a submarine cable almost invariably exclaims, with some instinctive dismay, "But does that mean we shall be dependent on the French for our power?" This leads his engineering friend to set out the whole of the economic argument for the interconnection, based as it is on the interchange of units at differing hours of peak demand; and most engineers (learning, as usual, while they teach) find they have produced an argument which is just as valid for a much wider electrical interconnection as it is for this one link between two systems only. In fact, international electrical interconnection is inevitably growing, irrespective of political divisions between neighbouring countries. It is perhaps of interest to try and examine the basic motives which lead electrical power engineers in different countries to link their systems together.

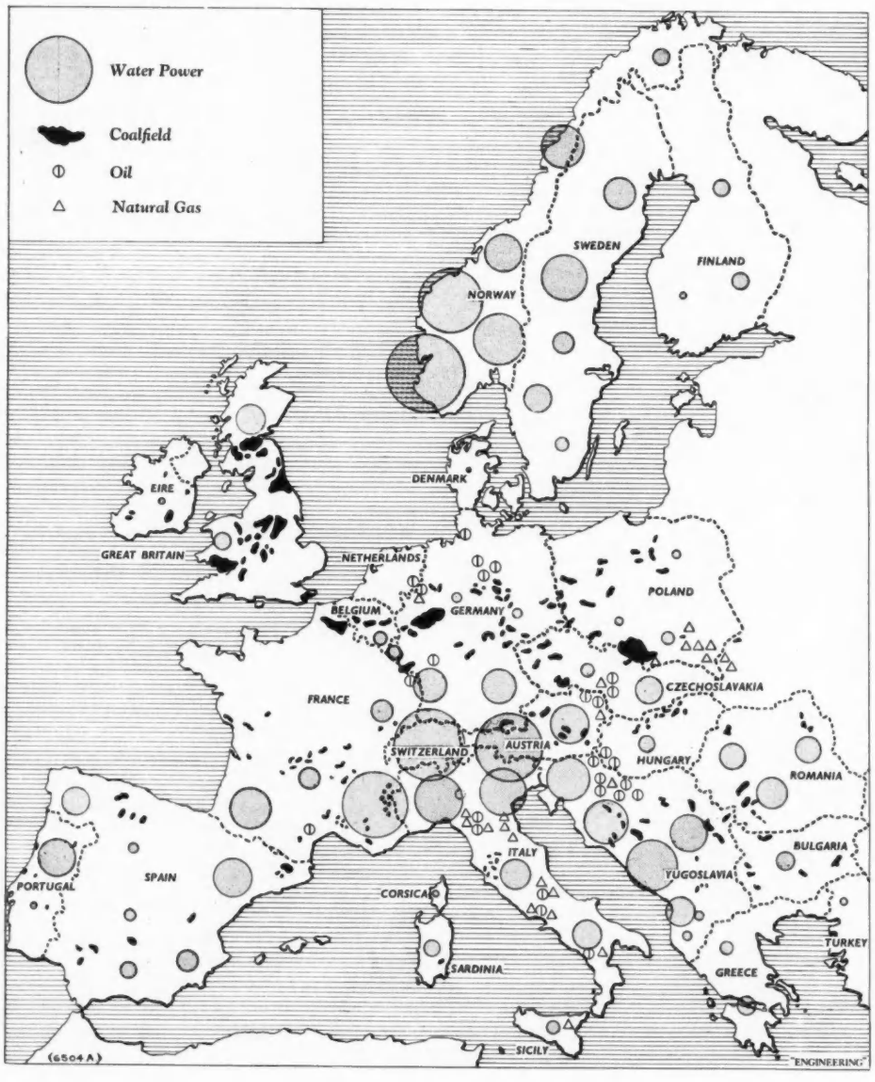
First, there is the obvious motive: lack of sufficient internal resources, whether of water power or fossil fuel. It might at once be asked if the availability of nuclear power does not redress the imbalance between power-producing resources and demands which exist in some areas; but arguments to the contrary will be set out in due course.

Secondly, there is the case where water power exists in reasonably ample quantity, but in such a form that there is inadequate storage of water to provide for dry periods: Spain is one country in which this condition applies.

Next, and most vital, is the need to improve the economics of power generation, a subject which can be considered under two associated headings: the sale and purchase of surplus units, marginally cheaper than those generated at any particular time in any particular system; and the most vital factor of all, the improvement of the load factor everywhere.

Electrical interconnection does of course exist at present between most European countries, but it is in general on a local scale, conditioned in many cases by the obvious need to balance out hydraulic irregularities between different parts of a catchment area which may extend into two or more countries.

Fig. 1 The energy sources of Europe.



NUCLEAR POWER NEGLIGIBLE

It is first desirable to try and forecast any factors which may change the electrical picture, and so militate against further interconnection. There are three questions:

(*a*) Will nuclear plants (as mentioned earlier) render interconnection obsolete, since power can be generated locally?

(*b*) Is saturation of electrical demand in sight, anywhere?

(*c*) Are there likely to be any significant changes in domestic or industrial usage of electrical energy which will affect the load curve so that advantages to be gained by interconnection will be lessened?

Nuclear power is unlikely to be so cheap in the foreseeable future that a major European programme will be undertaken (see Atomic Review). Since the percentage of nuclear plant will be comparatively small, its effect on the situation will be negligible. Indeed, the need for current nuclear power stations to operate at base load makes interconnection even more desirable.

In regard to the possibilities of saturation, so far the demand for electrical energy has doubled every ten years. This has apparently become a natural law, applying equally to underdeveloped countries and to the most highly industrialised regions, like the United States.

The American figures of consumption per inhabitant of 4,200 kWh per annum (second only to the special case of Norway, with no solid fuel and ample water power, whose figure is 7,400 kWh) show us how immeasurably far from saturation we are in Europe, with France at 1,300 kWh per inhabitant per annum, Portugal 250, Spain 470 and Great Britain with 1,950.

Assuming that all Governments wish to raise the standard of living of their peoples, then there is no logical reason why they should not ultimately need at least as much electrical energy per inhabitant as the citizens of the United States.

Domestic consumption can scarcely be altered, in regard to incidence of loading, to a significant extent. Night storage of hot water, and underfloor heating systems with properly insulated dwellings may have a small effect, but the continuing growth in electrical domestic equipment, all needed at much the same time of day, will inevitably tend to preserve the shape of the domestic load curve.

In industry, two factors could change the present load factor, assessed recently for British industrial demand at no more than 18 per cent on the average. Shift working, the first, could effect a radical change, but any moves to institute large scale night work would probably meet with severe antagonism from both workers and their families. The second factor would be the introduction of new electro-chemical and electro-metallurgical processes, demanding very large amounts of energy for long continuous periods. This type of load, with few exceptions, has so far existed only in those countries where very cheap water power has existed in conjunction with ample supplies of raw material nearby.

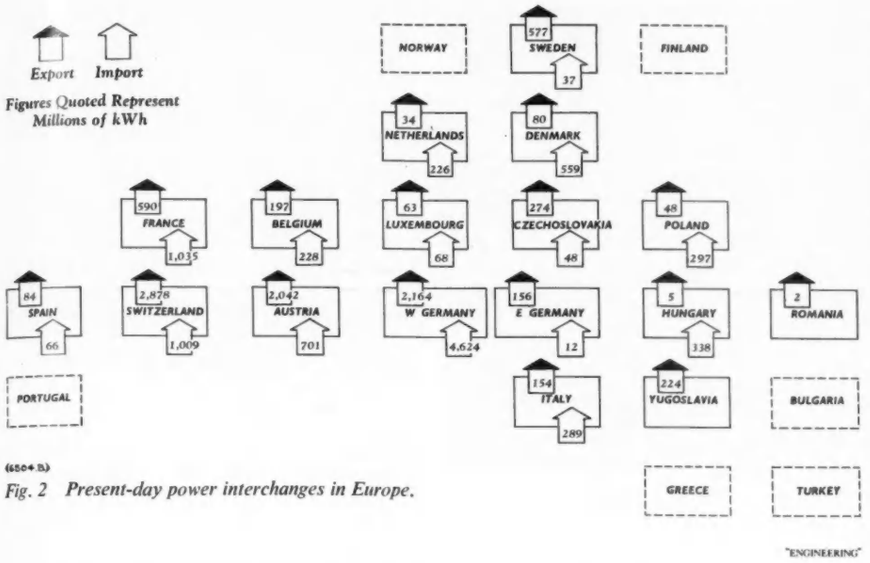


Fig. 2 Present-day power interchanges in Europe.

Having now discussed the factors which might have militated against increased European interconnection, we can now turn to the positive factors.

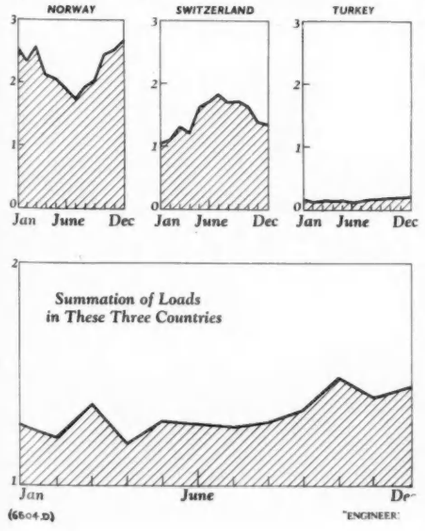
Fig. 1, compiled from OEEC sources, indicates the random disposition of energy resources in Europe. The water power circles indicate the potential amount of water power available. In several countries where hydro-power is the predominant source of energy, the most recent assessments show that exhaustion of all economically exploitable resources is within sight; in Switzerland, 10 to 15 years has been forecast, in Italy 12 years and Sweden 20 years. On the other hand, Norway, Austria, Yugoslavia, and Portugal have so far harnessed less than 20 per cent of their total available hydraulic energy.

Thus we can see groups of countries in Europe, not related geographically or politically, some with a present or imminent deficit in natural resources, others with a comfortable surplus. From that standpoint alone, and ignoring other considerations, power exchange would seem to be eminently desirable.

SEASONAL EXCHANGES

The majority of the power interchanges that take place at the present time in Europe, indicated in Fig. 2, relate to redressing the seasonal unbalances between hydraulic systems with differing characteristics. France and her neighbours provide a text-book case for interconnection on the grand scale. The 1958 figures for France show an export of 630×10^6 kWh and an import of $1{,}030 \times 10^6$ kWh, in relation to a total consumption of $62{,}200 \times 10^6$ kWh.

Fig. 4 The benefit of interconnection.



The geographical situation in which France is fortunate enough to find herself embraces hydraulic conditions of great variety, and there are important coal reserves in the north. The fortuitous discovery of natural gas at Lacq, near the Spanish border, in a predominantly hydro-electric area brings in another factor leading to greater emphasis on bulk power transmission

The imports and exports with France's neighbours may be considered as an extension of the exchange of energy between the three great areas of French hydro-electric development, the Alpes, the Pyrénées, and the Massif Central, and between the hydro-electric south and the thermal north. A striking diagram given in the 1958 annual report of Electricité de France, and reproduced here as Fig. 3 shows the difference between the energy exchange pattern in periods of "good" hydraulic conditions and those of "bad" conditions. The movements of energy to neighbouring countries are made for the same reasons, and bring the same benefits (even if imports and exports cancel out during any one year): improved reliability of supply; better use of storage in hydro stations; and more efficient use of thermal stations, avoiding long periods of running at low and uneconomical load factors.

Under this heading it should also be mentioned that an interconnection system enables any new source of power to be utilised much nearer its maximum efficiency than would be possible were it to operate as an isolated entity. Examples which may be mentioned here are the utilisation for electrical power generation of some of the natural gas from the Lacq deposits; the tidal power plant planned for the Rance estuary; peaking plant consisting of gas turbines; the geothermal power plant at Lardarello in Italy; and wind power and solar energy installations wherever they may come to exist. Each of these has special characteristics which can usually only be exploited to the best advantage if the prime movers concerned are run in parallel with a large network.

IMPROVED LOAD FACTORS

The final—and in the writer's view, the most important—reason for continually extending power plant interconnection is the imperative need to improve load factor everywhere.

It is arguable that in the next decade no "service" industry in Western European countries will demand as great a share of the annual national capital investment as that of the electricity supply. Yet the degree of utilisation of the plant is still only of the order of 47 per cent—the current load factor in Great Britain, and one which does not greatly differ from that in other European countries.

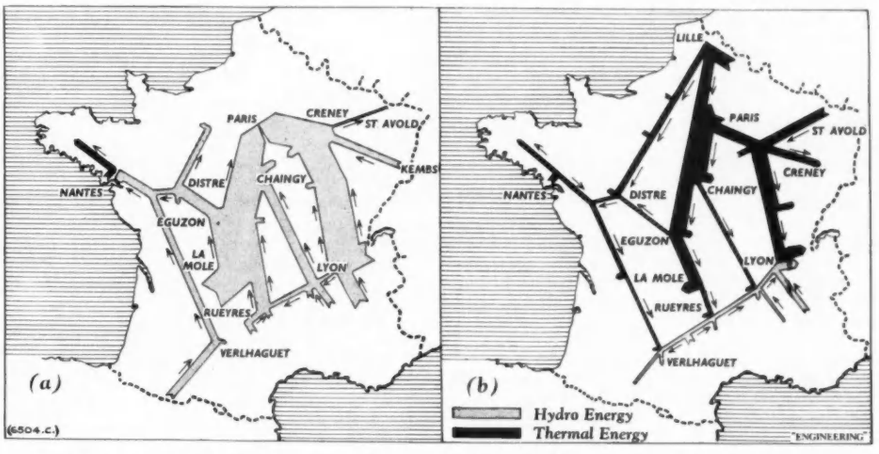


Fig. 3 Power interchange patterns during "good" hydraulic conditions (left) and "bad" (right).

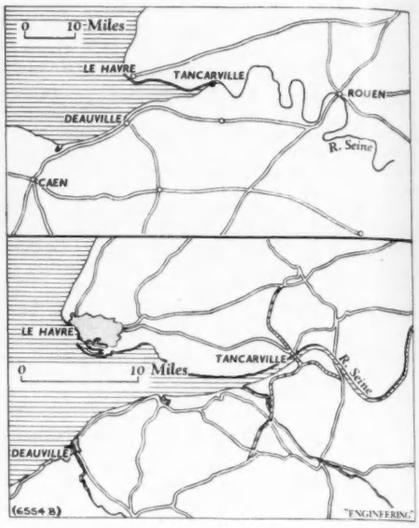
It has been suggested earlier that no change in consumer requirements is likely to alter the daily, monthly or annual load curves to a significant extent. Thus the supply authorities in any one zone can do little to improve load factor, except to offer night tariffs which are as attractive as possible.

The greatest possible benefit can come from the interconnection of zones with different climates, different clock times, and different industrial demands.

A striking example of the benefits of interconnection can be seen from the combination of charts showing the monthly variation in power production between two countries. In Fig. 4 there is shown the annual production figures for 1957-58 for Norway, Switzerland and Turkey. If it is now imagined that a gigantic super-grid system could couple these three countries together, the total annual load curve, as it would appear to a single station supplying all three countries, would appear as shown in the figure.

To sum up, improved load factor can bring great benefits, but in the writer's view can only be achieved to any significant extent by interconnection; thus there exists the strongest possible incentive to interconnection on the widest possible scale. The benefits obtained are independent of the type of power source employed, but are perhaps greatest where there are high cost nuclear and hydro plants on the system.

The completed bridge, with the flat southern bank beyond.



(Right) Location maps.

TANCARVILLE — *Europe's Largest Suspension Bridge*

Tancarville road bridge, with its 2,000 ft span over the Seine estuary making it the longest suspension bridge in Europe, was opened to traffic in mid-July. Of its many new features the most interesting are the 390 ft high towers constructed in reinforced concrete, the first time concrete has been so used on a bridge of this magnitude; the main cables made up from wire ropes; and the composite construction of the suspended structure.

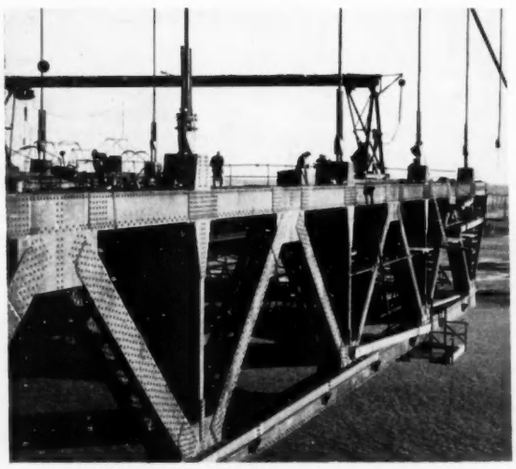
As will be seen from the sketch maps the bridge is sited 20 miles from the mouth of the River Seine. Before its construction the first road crossing of the river was at Rouen, nearly half way to Paris, though there were also some poor ferry crossings. The motorist's route between Le Havre and Deauville has now been shortened by about 60 miles and for the first time since the Revolution tolls are to be charged in France. Pedestrians, cyclists and large animals will pay 40 frs (about 7*d*), small cars 400 frs (5*s* 9*d*), medium sized cars 650 frs and large cars and commercial vehicles 900 frs.

The capacity of the bridge is 20,000 vehicles in 24 hours; over the first few weeks about 22,000 vehicles were crossing the bridge a week with tolls amounting to £12,500. Apart from the new approach roads, the project cost 8,000 million frs (£5,700,000), and the Chamber of Commerce of Le Havre, by whose campaigning s the bridge has come into being, expect the capital and interest charges to be recouped in under 25 years. Like all major bridges it has a long history for it was first proposed as early as 1848; objections, principally from Rouen which controlled the lower Seine traffic, held up all considerations until the 1920's when the first detailed designs for a suspension bridge were produced; in 1931 a tunnel was proposed but turned down on account of cost; and in 1935 the Chamber of Commerce renewed their demands for state assistance in building the bridge at Tancarville. It was not, however, until 1951 that the concession was finally obtained although some preliminary work on the approaches had been started during the 1940's. Following a design competition held during 1952 a consortium of 12 French firms were given the contract which was begun in 1956. The bridge was opened to traffic on 14 July and officially inaugurated by the French Minister of Works on 25 July—eight days before the contract was due for completion.

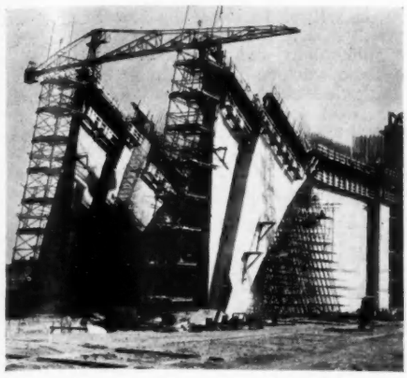
The site of the bridge is most interesting. On the south bank the land is an alluvial deposit and quite flat for many miles in every direction and this has necessitated a steep (1 in 15) approach in the form of a concrete viaduct. The north bank, however, is distinguished by a rocky promontory that approaches close to the river ho re. For this reason the two cable anchorages are quite different. On the rocky north side it is of a conventional type with cable tunnels embedded in the rock. At the south side, however, a massive concrete block weighing (including ballast) 35,500 tonnes, has been erected, its top surface forming the connecting link between the bridge deck and the viaduct. This block is hinged on a neoprene pad at its "toe" where it is carried on the foundation caissons. The pull in the cables (8,000 tonnes in each) is countered by the moment of the weight of the anchorage about the hinge and the articulation about the toe permits temperature movements to be taken up.

The main suspended structure is a large riveted box girder continuous over the two side spans of 572 ft and the centre span of 2,000 ft. (This span should be compared with the 4,200 ft of the Golden Gate, San Francisco, and the 4,260 ft of the New York Narrows bridge on which work was begun during this last month; the new Forth Bridge will have a centre span of 3,300 ft when it is completed in 1962, and permission to build has now been given for the Humber bridge that will be the longest anywhere in the world, 4,500 ft). The clearance at Tancarville over high water is 160 ft which gave ample room for a helicopter to fly under the bridge immediately after the opening ceremony. The composite steel sheet and concrete deck acts as the top chord of

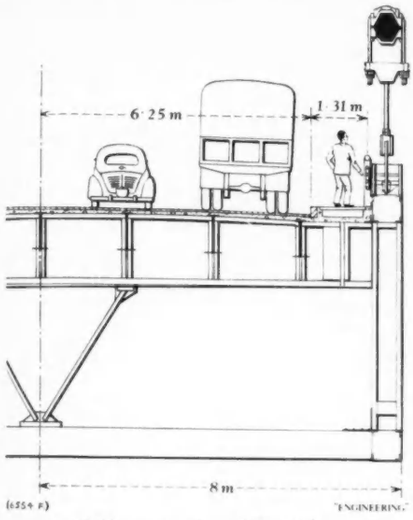
The heavily riveted main girder.



Erection of the main girder began simultaneously at the towers and at midspan.



The south-bank anchorage under construction.



Half cross-section of the bridge.

the stiffening truss which is further stiffened by rigid connections to the cables at the centre of the span. Extensive wind tunnel tests have shown that the bridge can withstand a uniform loading from a gale blowing up to 450 m.p.h., at which speed critical oscillations are likely to occur; the highest known wind speed in the area is about one-quarter of this.

Two types of live loading, apart from wind loading, were considered for calculating the dimensions of the suspended members. First was the point loads which dictate the thickness of the deck slab and stringer sections; these loads are the same as are considered for all French bridges and are laid down in a circular of the French Ministry of Works. Second was a uniformly distributed load for calculating the main girder dimensions, cable size, foundations, and so on. For Tancarville this loading was specified as 400 kg per sq. m (90 lb per sq. ft), acting over the whole width and length of both road surface and footpath. With a full width between hand rails of about 50 ft this represents a live loading of 6 tonnes per linear metre of the bridge for the whole length of the bridge. For appropriate calculations this figure was also further increased by the application of a dynamic loading coefficient. By British standards, and including the criterion for wind loading, this would appear to lead to a strong structure, for in the United Kingdom some relief would be allowed because of the great length of the bridge and the coexistance of four traffic lanes.

A small but interesting point of the design—which can be seen in the photograph of the main girder steelwork—is the fitting of I-beams along the bottom outsides of the main girders to act as rails for a painter's trolley that hangs below the bridge and can be traversed along the whole length of the spans.

As has already been recorded major works were begun in March, 1956. Some difficulty was met when sinking the caisson for the south bank foundations in the water-logged aluvium and work had to be carried on using compressed air; the surrounding ground was also strengthened by injecting a cement grout. The towers were completed by March, 1958, and the cables slung during the following six months, each cable comprising 56 wire ropes over the central span and 60 ropes over each side span. Each through rope, 3,500 ft long and weighing 27 tons, was erected by pulling it across the opening while it was supported by monowheels from a higher temporary ropeway.

Finally in the 10 months from August, 1958, the main spans were erected (starting simultaneously at the towers and mid-span), the road slab placed and the asphalt wearing surface laid. The bridge was finally inaugurated, with much ceremony, on 25 July.

Construction Work on the Indus

Considerable civil engineering construction will take place in the Indus Valley during the next ten years or so, if, as is to be hoped, an acceptable solution is found to the problem of equitably proportioning the waters of its various rivers between India and Pakistan. Preliminary engineering studies, carried out under the auspices of the World Bank, indicate that six canals, three dams and two reservoirs, each a major undertaking, are likely to be required. Most of these works will be sited in Pakistan, although at least one of the dams is expected to be in India.

It is probable that some of the technical assistance required will be sought from Great Britain, the United States and West Germany. The total cost of the projects, as stated in the Weekly Survey on an earlier page in this issue, is expected to be in the neighbourhood of £350 million.

Wide Acceptance of ICE Conditions of Contract

It is known that over 70 per cent of local authorities now use the Institution of Civil Engineers' *Conditions of Contract* for letting their civil engineering contracts. During the last 12 months 60 local authorities adopted the *Conditions*, bringing the total to 1,197 (70 per cent); in the same period the Dock and Harbour Authorities' Association also decided to recommend it to their members. The *Conditions of Contract*, which include standard forms of tender, agreement and bond, have been jointly agreed by the Institution, the Association of Consulting Engineers and the Federation of Civil Engineering Contractors.

Northern Alignment for London-Yorkshire Motorway

The Minister of Transport has decided to proceed with the preparation of a draft scheme for the northern section of the London-Yorkshire motorway (from Crick, near Rugby, to Doncaster, a distance of 86 miles). The chosen line, as far as Leicestershire is concerned, follows the route proposed by the County Council and sacrifices some engineering and traffic considerations to the local demands of agriculture and amenity.

Sir Owen Williams and Partners, the consulting engineers, are to produce details so that the draft scheme can be advertised before the end of the year. It will then be decided if a public inquiry is to be held. Motorway experience will be available by then, giving further opportunity for more delay.

Training in Safety on Site

The Federation of Civil Engineering Contractors has established a training course in safety on civil engineering sites; it is designed for all supervisory grades, including young engineers. Collaborating with the Federation are the Factory Inspectorate, the Birmingham Industrial Safety Group and the London Building and Engineering Contractors' Accident Prevention Group.

The course lasts two days and will be held four times this autumn; twice at Birmingham and twice at Enfield, near London. Subjects to be discussed include both the causes and costs of accidents, as well as their prevention.

Steel Bridge over River Niger

The first direct link between the east and west of Nigeria will be made by the construction of a road bridge over the Niger. The bridge is to be built by Taylor Woodrow (Nigeria) Limited, who are to finance the project. Work will start in November and take four years to complete.

The bridge will have a steel superstructure of 10 spans, each 427 ft long, carried on reinforced concrete piers. It will have two carriageways and footpaths with concrete plank decking and wearing surfaces; the width is 68 ft. Consulting engineers for the project are the Netherland Engineering Consultants of The Hague, Holland.

Northern Approach to Dartford-Purfleet Tunnel

A contract has been let to Edmund Nuttal, Sons and Company (London) Limited for the first part of the northern approach to the Dartford-Purfleet Tunnel. Nuttals are the contractors for the tunnel itself. The consultants for the project are Mott, Hay and Anderson, and Coodes and Partners.

The work includes a reinforced concrete viaduct providing two 24 ft carriageways, a two-way track 15 ft wide for cyclists, and a small footway. Of the 21 spans, 17 will be of a uniform pattern, having a continuous deck of shallow construction. Precast prestressed beams will carry the route on the four spans over a railway. The piers will rest on reinforced concrete piles.

Ground Movements: Proceedings of European Congress

The problem of ground subsidence in the winning of coal and other deposits was the subject of a congress held at Leeds University in 1957, sponsored by the university and the National Coal Board. Altogether 23 papers were presented by leading authorities from Great Britain and the Continent. These papers, and the discussions that ensued, are contained in the *Proceedings* which are now published; copies are available from the Department of Mining, University of Leeds (2 *gns*, post free). The volume is the most authoratative book on the subject and is a practical handbook rather than a theoretical treatment of ground movements.

Epoxide Pipes in Major Drainage Scheme

The drainage system from the flue-gas washing plant at Battersea power station, carrying effluent to the treatment unit before discharge into the Thames, has been replaced using 1,000 ft of large diameter reinforced epoxide piping. This is the largest installation of its type in Great Britain. The effluent contains a percentage of sulphuric acid and the pipes have been made from Bakelite epoxide resin reinforced with glass fibre and Terylene. Manufacture and installation of the pipework was by Mendip (Chemical Engineering) Limited.

Europe Undeterred

RECENT misgivings concerning the future of atomic power do not appear to have discouraged the Europeans. The Euratom nuclear power programme has found the necessary financial support and considerable nuclear activity continues to be reported from the Continent. The United Kingdom is involved in this activity through its agreement with Euratom and through the Organisation for European Economic Cooperation, particularly in connection with the Dragon project to be carried out at Winfrith Heath. The European scene and work at Winfrith Heath provide the subjects of this week's review.

Credit for Joint Euratom-US Programme

The Commission of the European Atomic Energy Community and the Export-Import Bank of Washington have signed agreements implementing the bank's $135 million line of credit to assist in financing the construction of nuclear power plants to be built under the joint United States-Euratom programme in the Community countries. The goal of the joint programme is a total installed generating capacity in the nuclear powered plants of approximately 1,000 MW. Under the terms of the joint programme these large scale plants will be completed and placed in operation by 31 December, 1963, except that two reactors may be selected to be placed in operation by 31 December, 1965. In addition to nuclear power development, the United States-Euratom Agreement provides for a programme of nuclear research and development to be carried out simultaneously for the six countries in cooperation with the United States, in both the Community and the United States. The total cost of the plants is estimated at $350 million. The $215 million required in addition to the Eximbank loan will be raised from European sources.

Conditions of Euratom Loan

The Export-Import Bank credit may be used to assist in financing the purchase of reactors of types developed in the United States to be installed in the six to eight nuclear power plants which will comprise the 1,000 MW programme and also for initial fuel fabrication and engineering services. Use of the credit will be limited to not more than 40 per cent of the total cost of any plant. Eximbank's credit will be repayable over 20 years. Interest charged will be at the rate of 4½ per cent annually. The bank explained that this is below its normal rate for development loans but has been established, with the concurrence of the US National Advisory Council on International Monetary and Financial Problems, in order to facilitate the advancement of the peaceful use of atomic energy. The Eximbank loan is one of a series of cooperative steps taken under the Agreement for Cooperation entered into between the United States and Euratom on 8 November, 1958, which became effective on 16 February of this year.

Joint Reactor Board

Under the agreement for cooperation between the United States and Euratom, a Joint Reactor Board has been established, composed of representatives of Euratom, the US Atomic Energy Commission, and the Export-Import Bank, to select the projects to participate in the programme. Proposals from utilities in the Community must be received by 20 October, 1959. After a project is approved by the USAEC and Euratom Commission upon the recommendation of the Joint Reactor Board, an application will be submitted by the utility selected—for these projects requesting financing—to Euratom for approval by the bank, of an allocation under the line of credit.

US—Euratom Power Plans

The Commission of the European Atomic Energy Community and the USAEC have announced that five firms—Belgian, French, German, Italian and Dutch—have expressed their intention to submit proposals under the common US-Euratom nuclear power programme. These proposals are concerned with the building of power reactors which are to be completed by the end of 1963.

Euratom-USAEC Defer Proposals Deadline

The United States Atomic Energy Commission and the Commission of the European Atomic Energy Community have announced that they have extended from September 1, 1959, to October 20, 1959, the deadline for definitive proposals for nuclear power projects to be brought into operation in the Community under the US-Euratom joint programme by December 31, 1963. The date was extended at the request of the Euratom Commission. The extension will permit interested Community utilities additional time to evaluate fully the bids of prospective reactor manufacturers, to make necessary arrangements with their respective governments, and to prepare their final proposals for submission to the joint reactor board.

US—Euratom Research Committee

The United States Atomic Energy Commission and the Commission of the European Atomic Energy Community have announced the formation of their Joint Research and Development Committee, whose task is to put into action the joint US-Euratom research and development programme. The aim of this programme is to secure lower cost energy from power reactors to be built in the Community, in accordance with the agreement of cooperation with the US, as well as to lower the cost of the fuel-cycle. It is also concerned with the recycling of plutonium and other problems relating to these reactors. The main functions of the Joint Committee are to examine, evaluate and select the proposals submitted, and give general technical direction to the work resulting from contracts. All the decisions of the Joint Committee will be taken by common agreement, Euratom and the USAEC having one vote each.

Firms Participating in US-Euratom

The United States-Euratom Joint Research and Development Office has received over 200 proposals and letters of intention from firms, research groups and institutions wishing to participate in the programme. The total sum involved in the definite proposals amounts to $37 million. The ten year research and development programme is one of the main elements in the US-Euratom agreement, and is valued at $100 million divided equally between the Six and the United States Government. The list of firms that have submitted proposals or signified their wish to participate in the programme includes the following.

(1) *Firms and Institutions in the Community*

Bureau d'Études des Combustibles Nucléaires (BECN)	B
Centre Belge d'Études et de Documentation des Eaux (CEBEDEAU)	B
Centre d'Études de l'Energie Nucléaire (CEN)	B
Centre Ricerche Metallurgiche	I
Comitate Nazionale per le Ricerche Nucleari	I
Commissariat à l'Énergie Atomique (CEA)	F
Compagnie des Ateliers et Forges de la Loire	F
Compagnie Francaise Thomson-Houston	F
Fiat Sezione Energia Nucleare	I
Groupement Indatom which includes:	F
Société Francaise des Constructions Babcock et Wilcox Banque de Paris et des Pays-Bas Compagnie des Ateliers et Forges de la Loire and various other companies.	
Hahn-Meitner-Institut fur Kernforschung Berlin, Sektor Kernchemie	G
La Métallurgie Francaise des Poudres	F
Manufacture de Produits Chimiques du Nord—Establissement Kuhlmann	F
Maschinenfabrik Augsburg-Nurnberg (MAN)	G
Merisinter	I
Metallgesellschaft M	G
Métallurgie et Mécanique Nucléaires (MMN)	B
Nijverheidsorganisatie TNOQ	N
Pechiney, Compagnie de Produits Chimiques et Electrométallurgiques	F
Reactor Centrum Nederland	N
Société Belge de l'Azote et des Produits Chimiques du Marly	B
Société Belge pour l'Industrie Nucléaire	B
Société des Forges et Ateliers du Creusot	F
Société d'Etudes de Recherches et d'Applications pour l'Industrie	B
Societè Elettronica Lombarda	I
Société Générale de Constructions Electriques et Mécaniques Alsthem	F
Société Nationale d'Études et de Construction de d'Aviation	F
Société pour les Applications Techniques dans le Domaine de l'Energie Nucléaire	F
Staatsmignen in Limburg	N
Transporatome	F
Union Chimique Belge	B
Battelle Memorial Institute, Division Internationale	S

TABLE I.—*Power Reactors in OEEC Countries (Reactors in Operation, under Construction or Projected)*

Country	Location	Designation	Type	Criticality	Owner	Designer	Fuel	Moderator	Cooling Agent	Outlet temp., °C	Pressure, lb per sq. in	Power MW thermal	Power MW electric
Belgium	Mol	BR3	PWR	1960	CEN	Westinghouse (USA)	2·8t UO_2 4·5 per cent enriched	H_2O	H_2O	271	2,000	43	10·5
France	Marcoule	G1	Gas-graphite	Sept. 1956	CEA	CEA	100 t U nat.	Graphite	Air	200	Atm.	40	5·1
,,	,,	G2	,,	July 1958	,,	,,	,,	,,	CO_2	255	213	150	30
,,	,,	G3	,,	1959	,,	,,	,,	,,	,,	255	213	150	30
,,	Chinon	EDF1	,,	End 1959	EDF	EDF	140t U nat.	,,	,,	345	356	300	63
,,	,,	EDF2	,,	1961	,,	,,	250t U nat.	,,	,,	345	356	700	170
Germany	Kahl (Frankfurt)	—	BWR	End 1960	RWE	GE-AEG	6·4t UO_2 2·6 per cent enrichment	H_2O	H_2O	285	100	—	15
Italy	Latina	SIMEA	Gas-graphite	1962	SIMEA	NPPC	245t U nat.	Graphite	CO_2	390	196	711	200
,,	Punta Fiume	SENN-ENSI	BWR	1963	SENN			H_2O	H_2O	274	2,000	—	150
,,	—	SELNI	PWR	1961	SELNI	IGE (USA)	UO_2 enriched	H_2O	H_2O	—	—	482	134
Sweden	Stockholm	R3-ADAM	D_2O	1960-61	AB Atom-energi	Westinghouse	27·5t UO_2	D_2O	D_2O	220	500	(*a*) 65 (*b*) 125	(*a*) 10 (*b*) 36/47
,,	Tiveden	R4-EVE	D_2O	1965	,,	AB Atomenergi	UO_2 nat.	D_2O	D_2O	—	—	350–700	100–200
						AB Atomenergi-ASEA-NOHAB/BOFORS	UO_2 nat.						
United Kingdom	Calder Hall	Calder Hall A1	Gas-graphite	May 1956	UKAEA	UKAEA	U nat.	Graphite	CO_2	336	100	180	35
,,	,,	,, ,, A2	,,	Nov. 1956	,,	,,	,,	,,	,,	,,	,,	180	35
,,	,,	,, ,, B1	,,	March 1958	,,	,,	,,	,,	,,	,,	,,	180	35
,,	,,	,, ,, B2	,,	Dec. 1958	,,	,,	,,	,,	,,	,,	,,	180	35
,,	Chapelcross	Chapelcross (4 reactors)	,,	During 1959	UKAEA	UKAEA	,,	,,	,,	,,	,,	180	140 total
,,	Berkeley	Berkeley (2 reactors)	,,	1960	CEGB	AEI-JT	,,	,,	,,	345	125	550 per react.	4 react. 275 total
,,	Bradwell	Bradwell (2 reactors)	,,	1960	CEGB	NPPC	,,	,,	,,	390	147	530 per react.	2 react. 300 total
,,	Hinkley Point	Hinkley Point (2 reactors)	,,	1961-62	CEGB	EE-B & W-TW	,,	,,	,,	373	185	980 per react.	2 react. 500 total
,,	Hunterston	Hunterston (2 reactors)	,,	1961-62	SSEB	GEC (UK)-SC	,,	,,	,,	395	150	535 per react	2 react. 300 total

(2) *United States Firms*

Aerojet General Corporation
Advanced Technology Laboratories
Armour Research Foundation
Atomics International
Battelle Memorial Institute
Cornell Aeronautical Laboratory Incorporated
General Electric Company
Harvey Aluminium Corporation
Internuclear Company
North Carolina State College
Nuclear Science and Engineering Corporation
Pennsylvania State University
Radiation Applications Incorporated
Rensselaer Polytechnic Institute Standard Railway Equipment Manufacturing Company
Sylvania Corning Nuclear Corporation
Thefluor Corporation Limited
Turco Products
Electro Metallurgic Cal Company, a Division of Union Carbide Corp.

(3) *Joint Community—US Firms*

Ateliers de Constructions Electriques de Charleroi (ACEC) & Westinghouse	B + U
Centro Informazioni Studi Esperienze (CISE) & Ansaldo	I
Cockerill Ougreé & Westinghouse	B + U
Montecatini, Societá Generale per l'Industria Mineraria e Chimica & CNRN & Internationale Atomreaktorbau (Interatom) & Atomics International	I + I +G+ U
Société Belge pour l'Industrie Nucléaire Belgo-Nucléaire	B
& Centre d'Etude de l'Energei Nucléaire	B
& Atomic Power Development Associates	U
Groupement Indatom & Babcock and Wilcox	F + U
Métallurgie et Mécanique Nucléaires	B
& Westinghouse	U
& Ateliers de Constructions Electriques de Charleroi (ACEC)	B

Key: B—Belgium, F—France, G—Germany, I—Italy, N—Netherlands, S—Switzerland, U—USA.

Research Contracts for US-Euratom

The US-Euratom Joint Research and Development Board have announced the award of contracts totalling approximately $315,000 to three United States and European research institutions and industrial firms. The awards represent the first contracts to be negotiated under the US-Euratom Joint Research and Development Programme. They are as follows.

American Standard Corporation (*US*): clad ceramic plate fuel elements by spray-coating techniques.

Battelle Memorial Institute (*US*): boiling heat-transfer and void distribution studies with water coolants.

Compagnie Industrielle des Céramiques Electroniques (*France*): study project on the extrusion of uranium oxide.

Euratom Joint Research Centre at Ispra

An agreement for the establishment at Ispra (northern Italy) of part of the Euratom Joint Nuclear Research Centre has been signed in Rome by representatives of the Italian Government and the Euratom Commission. This agreement will allow the Commission to make a rapid start on its own research programme. It intends to carry out the major part of its research at Ispra in the next three years, but negotiations are continuing in the meantime with the Federal German and Dutch Governments for the establishment of other parts of the Joint Centre at Petten (north of Amsterdam) and Karlsruhe.

Euratom Nuclear Materials Accounting

A recent issue of *Journal Officiel* (Euratom) gives a new regulation covering the accounting procedure of the six countries of Euratom. This is an essential part of the control system for nuclear materials. The new regulation specifies the nature of the information which must be regularly passed to the Euratom Commission about the quantities and location of uranium and thorium ores within the Community, and the raw and fissile materials which derive from them. The information also covers the transformation processes through which they pass, transfers of such material between the six countries and exports outside the Community. The regulation leaves producers and users free to devise their own internal accounting system on condition that this enables them to furnish the information the Commission requires. In the agreements made last year between Euratom and the United States and the United Kingdom, the Euratom control system was recognised. This was the first time that either Britain or the United States had *not* kept control of the use of materials they furnished to other countries under bilateral agreement.

British Resident Attaché with Euratom

Mr. D. H. Hill, of the United Kingdom Atomic Energy Authority, has been appointed resident nuclear energy attaché to Mr. A. H. Tandy, the United Kingdom Government's representative to the European Atomic Energy Community (Euratom) in Brussels. He took up his appointment on 1 June. The Government appointed a permanent representative to Euratom last year. The agreement between the United Kingdom Government and Euratom, which was signed in London on 4 February, provides for close collaboration between the parties for the promotion and development of the peaceful uses of atomic energy within the Euratom community and the United Kingdom.

OEEC-Euratom Association

Reports from Paris conferences organised by OEEC and ENEA suggest that OEEC and Euratom projects for developing nuclear power in Europe will be amalgamated by 1964. France may build the 10 million plus uranium processing plant required for OEEC; and the Eurochemic uranium processing plant may not come into operation before 1963. The cost of processing fuel is expected to be of the order of £7 per kg. The OEEC fuel fabrication plant is to be at Mol as already decided.

Forecast of European Nuclear Energy Costs

Estimates of Nuclear Energy Production in Europe 1958-1965: National Programmes Basis for Calculating Capital Costs Cost Factors is the title of a recent analysis published by OEEC. The booklet examines installed capacity, nuclear fuel requirements, fuel costs, capital investment, forecasts for 1975, programmes of the OEEC countries, and comprehensive details of cost calculations. It is estimated that by 1960 the production cost of electricity would be between 8·5 and 15 mills per kWh for stations using natural uranium (specific capital cost $400 per electrical kW) and for those using enriched uranium (specific investment $350 per electrical kW). Assuming that specific capital costs could be brought down, by about 1965, to $300 per kW for power stations using natural uranium and to $280 for those using enriched uranium, the production cost of electricity would probably then be between 7 and 12 mills per kWh for stations using natural uranium and between 8 and 13 mills per kWh for those using enriched uranium. These figures correspond fairly well with UK and US estimates. The figure chosen for financial charges was an annual rate of 14 per cent, based on the financial terms adopted in Italy for the SENN project.

TABLE II.—*Cost of European Projects in EMA Units (equal to $)*

	Total	Per kW
Belgium BR3	10 million	1,000
France G1	23 million	4,500
„ G2	30 million	1,000
„ G3	30 million	1,000
„ EDF-1	33 million	500
„ EDF-2	60 million	350
Italy SIMEA	80 million	400
„ SELNI	25 million	186

European Reactors Compared

Major power reactors in operation, building, or with contracts signed in the OEEC countries are listed in Table I. Table II compares the costs of the Continental projects. The tables have been compiled from details given in the OEEC booklet described in the previous paragraph; *Directory of Nuclear Reactors* published by the International Atomic Energy Agency; and *Report on the Position of Nuclear Industries in the Community* issued by Euratom. The Euratom report covers fuel and special material resources, research and power reactors, radioisotopes, economics of the atomic energy industry, and national and international organisations as they concern the Euratom countries.

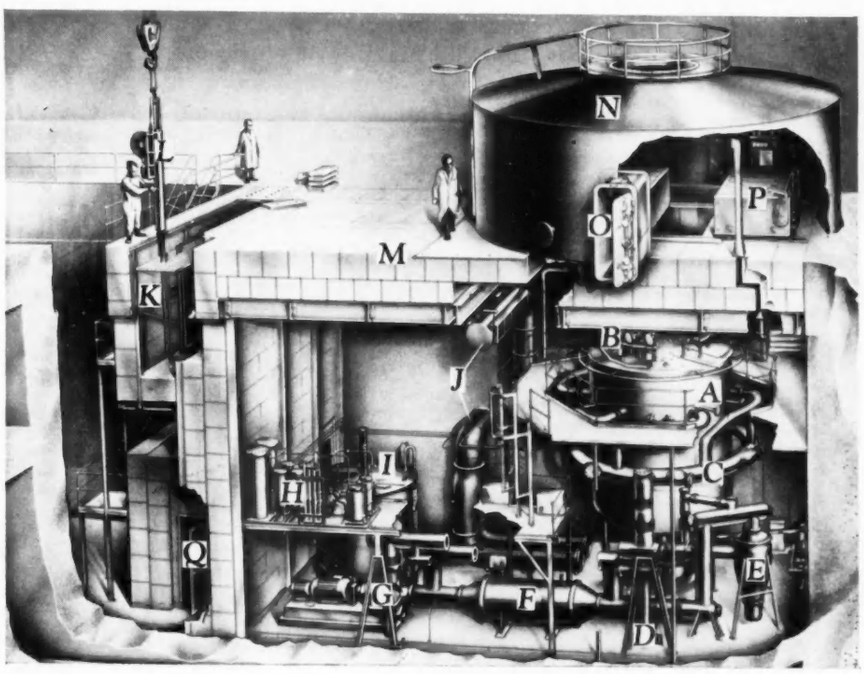


Fig. 1 Arrangement of the zero-energy reactor Zenith, a predecessor of the high-temperature gas-cooled reactor to be built under the European Dragon project.

A Reactor vessel
B Control rod mechanism
C Nitrogen supply to reflector
D Nitrogen supply to heater
E Nitrogen filter
F Heat exchanger
G Nitrogen circulator
H Nitrogen purification plant
I Nitrogen gas holder
J Waste heat ventilation system
K Fuel element store
L Load-unload flask
M Concrete block shield roo
N Containment dome
O Air lock access to dome
P Shield trolleys
Q Labyrinth entry to contained space

OEEC Projects

The OEEC Halden boiling-heavy-water reactor project discussed last week is one of several joint undertakings sponsored by the European Nuclear Energy Agency of OEEC; others are the Eurochemic company for the chemical processing of irradiated fuels (established by an international convention signed in December, 1957) and the Dragon high-temperature gas-cooled reactor project, work on which began last April. With the entry of Spain into OEEC, the capital of Eurochemic has been increased from $20 million to $21·5 million.

Eurochemic

Participants in Eurochemic, the European Company for the Chemical Processing of Nuclear Fuels, are Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and Turkey. A sufficient

number of ratifications have now been received (80 per cent) to permit the company proper to come into being. The company, which embraces both public and private capital (total now 21·5 million European Monetary Units of Account, equivalent to $21·5 million), is to build a $12 million irradiated fuel processing plant at Mol in Belgium.

Winfrith Heath

Winfrith Projects

The Winfrith Heath establishment of the United Kingdom Atomic Energy Authority is to be the site of the OEEC Dragon Project, devoted to the study and construction of a high-temperature gas-cooled reactor. The design of this reactor was described in a full length article published in ENGINEERING on 12 September 1958 (page 336). Waste disposal from Winfrith was discussed in a note entitled "Exercise Mermaid," which appeared in Atomic Review on 14 August. Winfrith has a large-scale electrical network analogue computer, which is used for solving problems in reactor kinetics. Known as PACE, it was made by Electronic Associates Limited. As a preliminary to the prototype HTGC reactor, a zero energy reactor has been built, known as ZENITH.

Zenith Completed

The construction of ZENITH, the zero-energy high-temperature gas-cooled reactor experiment at Winfrith, has recently been completed. Apart from the reactor core, which was wholly the responsibility of the UKAEA, the detailed design of the reactor was carried out by the General Electric Company Limited. Close control of coolant temperature and good insulation were important features of design and construction. Operation of the reactor is expected to begin in September.

Details of Zenith

Fig 1 shows the general arrangement of ZENITH and details of the coolant system are indicated in Fig. 2. Fig. 3 shows the top of the reactor core as it appeared in early June. In the past, experiments to study power reactor designs have been carried out in zero energy reactors operating at room temperature; although this is satisfactory for modest reactor temperatures, the degree of extrapolation involved in assessing the behaviour of high temperature systems is unacceptable. ZENITH is a zero energy reactor which is being built to operate under temperature conditions similar to those expected in a high temperature power reactor. The ZENITH core consists of fuel elements arranged in the same manner as those used in exponential experiments; the fuel elements used differ in that the ends of the ZENITH elements are made of solid graphite. The ends of the fuel elements and a 3 ft thick graphite annulus surrounding the fuel form a reflector to return some of the neutrons escaping from the fuel into the core so reducing the quantity of fuel used. Nitrogen gas is circulated through the core from an external circuit mounted in a pit beneath the reactor vessel. The nitrogen is heated by a 250 kW heater as it enters the core to raise the core temperature to 800° C. At the top of the core the hot nitrogen is mixed with cooler gas before passing through the reflector; thus the reflector is kept at a maximum temperature of 400° C. At these temperatures it is most important to maintain the purity of the gas and a purification system is used to remove traces of carbon monoxide and carbon dioxide. The reactor itself will be operated at a maximum nuclear power of 100 watts; the nuclear heat produced is thus negligible in comparison with the energy used to heat the core. The instruments used in studying the core are placed at the inner edge of the reflector and a ring of 30 control rod holes surrounds the core. The operating power, 100 watts maximum, is sufficient for the nuclear physics measurements and is sufficiently low to avoid inducing such high activities in the fuel that rearrangement of the core would be difficult to carry out. Details of ZENITH are listed in Table III.

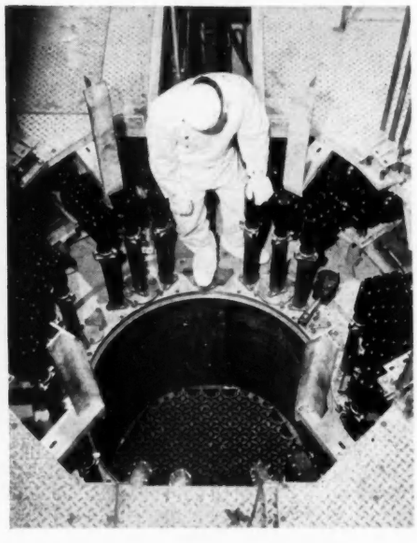


Fig. 3 Top of the Zenith core during construction.

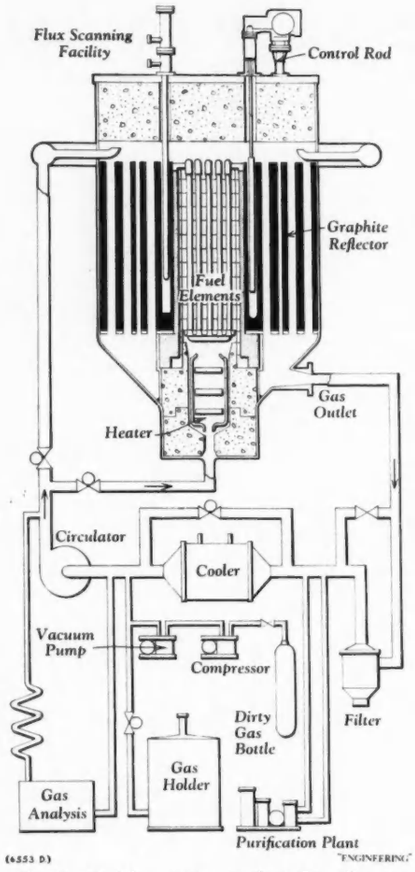


Fig. 2 Zenith: reactor coolant flow diagram.

Zenith to Dragon

The size and shape of ZENITH are almost the same as those of the 10 MW high-temperature gas-cooled reactor experiment which will be built at Winfrith for the DRAGON project. The initial programme of work with ZENITH, in which Authority and DRAGON staff will take part, will be carried out to determine the quantities important in the design of the DRAGON reactor experiment. Work on control problems, temperature coefficients and critical sizes will be of immediate application while measurements of neutron spectra and effective cross-sections will improve calculations of such effects as fission product absorption which cannot be observed directly in ZENITH. When this work is completed the reactor will be used for research in connection with the Authority's long term research programme on high-temperature systems.

TABLE III.—*Data for ZENITH*

Number of fuel rods	235
Number of control rods (20 motorised)	30
Core diameter (approximately)	4 ft
Length of core (maximum)	5 ft
Thickness of reflector	3 ft
Reflector material	graphite
Maximum temperatures:	
Core	800° C
Reflector	400° C
Coolant gas	nitrogen
Maximum neutron flux at 100 watts power	10^8 n per sq. cm per sec
Approximate cost of ZENITH	£350,000

Power and the Future

Stirring Up the Nuclear Business

Various readjustments are recommended in the report recently issued by the Select Committee on Estimates. The report considers in detail the work of the production group and the development and engineering group of the Atomic Energy Authority. The gross estimate for 1959-60 for the Authority was nearly £124 million, from which over £31 million was deducted by appropriations.

Partnership at Every Stage

While praising the work of the Authority, the committee observes that the relative positions of the UKAEA and industry are changing rapidly and urges that "the industrial group should respond to this changed position by bringing industry into closer partnership at every stage of development." The plans of the Authority to distribute research work increasingly to outside bodies, particularly in connection with studies at Dounreay, is welcomed by the committee. The report notes that it takes 10 to 15 years to develop a reactor system, consuming 1,000 to 2,000 man years of professional and specialist effort and costing between £10 million and £20 million; a further £20 million was required for building development facilities, research reactors and a prototype.

Counting the Cost

Extra costs—on additional safety measures and on compensating for the remoteness of the site—caused the Dounreay estimate to be revised upwards three times in four years, and is now 38 per cent higher than originally envisaged. Inadequate control there is believed to have cost some £500,000. The committee are also "concerned by the extra expenditure that the industrial group incurs by holding [stocks of uranium ore], and by the fact that these surpluses are being purchased, under contract at high prices, when supplies are becoming more abundant and prices are expected to fall."

Priority of the Fast Reactor

It is recommended that "the priority of the fast reactor should now be given special consideration ... The development of plutonium technology might increase the prospect of small reactors in competition with those from the United States." The committee emphasise the importance of solving the many technical problems associated with the fast reactor at the latest by 1966. It is hoped that a marine reactor system will be chosen so as to entail the least diversion of work from the power programme, though the possibility of developing two reactor systems for marine propulsion should be considered. (*The Fifth Report from the Select Committee on Estimates, Session 1958-59*, HMSO, 5*s*)

Capital Charges on Power Stations

Figures for the cost of Britain's nuclear power stations were given earlier this summer at the 11th British Electrical Power Convention, in a paper by Mr. F. H. S. Brown, a member of the CEGB, and Mr. J. Henderson, chief engineer of the SSEB, entitled "Progress on the First Nuclear Power Stations." Since nuclear power stations of the type being built would have a total cost of between £40 million and £70 million each, the capital charges towards the end of the construction period would be over £250,000 per month per station, and therefore every month in which non-productive costs could be replaced by revenue earning generation was of the utmost significance.

Contracts from the CEGB

It has been suggested that eventually the Central Electricity Generating Board will control the building of nuclear power stations in such a way that the nuclear power groups will no longer be required. In that case the overall design will be the responsibility of the CEGB, who will issue subcontracts as with conventional stations.

Break Even Point

Lord Plowden has stated that the break-even point for nuclear and conventional power stations is still expected to occur in the second half of the 1960's as originally estimated, though it is now likely to fall later in that period than was once hoped.

Plutonium Ceramics

The UKAEA regard plutonium ceramics as a promising reactor fuel for the future.

THERMOELECTRIC POWER

An Investigation of its Possibilities

By G. W. WILSON, B.Sc., Ph.D.,*
and B. C. LINDLEY, B.Sc.(Eng.)†

In an effort to solve the basic problems of converting heat directly into electricity, in a practical manner, research is now being carried out on a large scale. So far, encouraging results have been produced in two fields of study: thermoelectric generation and thermionic conversion. In these three articles the two methods are explained and the principles of operation and engineering design parameters for possible working systems are discussed. Examples of coupling these techniques to nuclear power sources are quoted with an approximate analysis of the economics.

Part 1 Present Methods of Power Generation

The present state of development of methods of electrical generation using direct conversion devices may be compared with the early days in the electricity supply industry when the attainable thermal efficiencies were extremely low and the plant crude and bulky. It seems reasonable to draw such a parallel when attempting to forecast the future trends for these devices.

A paper by Pearce[1] outlines the development of electrical power stations from about 1900, while recent information[2] brings the situation up to date. Fig. 1 shows the estimated thermal efficiencies, based on electricity generated, of the most efficient stations, from 1900 to the present.

The introduction of nuclear power has been accompanied by a reduction in thermal efficiency on account of the poorer steam conditions obtained with the present reactor systems. Development of high temperature systems will restore the thermal efficiency to the level at present attained in the best fossil-fuel plant, with a lag of ten or fifteen years.

Coal-burning stations cost £50 to £70 per kW installed and the largest and most efficient base-load stations produce electricity at about 0·5*d* per kWh. Steam stations using oil have similar costs but if the oil is used directly in diesel engines or gas turbines the maximum output of the unit is limited to about 20 or 30 MW (e) with a capital cost of £35 to £40 per kW installed. The cost of power from such units ranges from about 1*d* per kWh up to 3*d* per kWh in the United Kingdom.[3] Hydro-electric stations cost £100 to £130 per kW installed, with a very small running cost.

The capital cost of a large nuclear power station is about £120 to £140 per kW installed, for the CEGB stations now building, with an additional cost of the initial charge of fuel. At a load factor of 75 per cent the overall cost per unit is about 0·65*d* per kWh. Appreciable reductions in capital cost and increases in thermal efficiency may be expected for proposed reactor systems, with an attendant fall in the cost of power, becoming competitive with fossil-fuel stations within a few years.

It is anticipated that the capital cost of thermoelectric generating equipment will be less than that of steam-raising and turbo-alternator plant. If the thermal efficiency can be raised to the same order the cost of power will be lower, coupled with the important advantage that the only moving parts will be associated with auxiliaries, not a prime mover.

Thermoelectric Devices

Three principal thermoelectric effects were discovered over 100 years ago. In 1826 Seebeck found that an electric current flowed around a circuit consisting of two different electrically conducting materials when a difference in temperature was maintained between their junctions. This was followed in 1834 by Peltier's discovery that the passage of an electric current across the junction between two dissimilar conductors was accompanied by the evolution or absorption of heat. In 1855 Thomson predicted that a temperature gradient

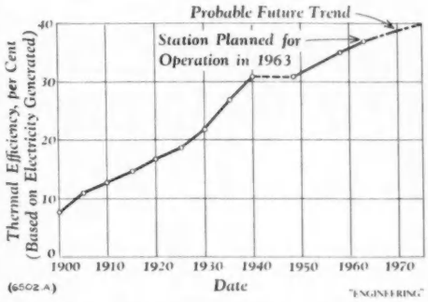


Fig. 1 Maximum thermal efficiencies of steam power stations in the United Kingdom.

existing in an electrically conducting material should be accompanied by a potential gradient.

It was apparent to many that the Seebeck effect, if large enough, could form the basis of a very simple method of converting thermal energy directly into electrical energy and, in 1885, Rayleigh gave an approximate theory, deriving the efficiency of such a process. Until very recently, however, the maximum efficiency obtainable was less than 1 per cent. This was due to the very low thermoelectric voltages generated in the available materials even with large temperature differences. Most of the electrical energy was used in overcoming the electrical resistance of the thermocouple materials themselves, accompanied by loss of most of the heat supplied, by thermal conduction from the hot to the cold junctions of the thermocouple, or thermopile.

As a result of work in solid state physics over the last 10 or 15 years a new class of materials, called semiconductors, has been developed, principally for other applications. From some of these new materials it has been found possible to construct batteries of thermocouples (thermopiles) using semiconducting compounds whose performances are many times better than the metals and alloys previously investigated. This has led to their use, in the USSR, on a limited scale at present, for direct electrical power generation. In America an Atomic Energy Commission spokesman is reported to have said that " the next 20 years should see the replacement of conventional electrical generating equipment by thermoelectric devices in nuclear power stations." Even more recently the development of a thermoelectri generator, having an efficiency of approximately 6 per cent, using fission product heating, was announced in Washington on 16 January this year. The project, known as SNAP III, is described in reference [4].

Thermionic Devices

The late Professor Owen Richardson was among the first to investigate systematically the emission of electrons from the surfaces of hot bodies in a vacuum. This emission was found to be dependent upon the temperature and certain electrical characteristics of the surface or emitter. Electrons could be collected by a cooler surface or collector, producing a potential difference between the two, so indicating the possibility of obtaining useful power. However, the maximum current which can normally be drawn from such an arrangement under an electrical field is always limited, in accordance with Richardson's equation (see later). In the absence of this accelerating electrical field some current can be drawn through a circuit externally connecting the hot to the cold surface. This current is generally infinitesimally small due to space charge effects. Recently a number of techniques have been suggested, and investigated, for overcoming the limitation set by this space charge, and for therefore increasing the current by many orders of magnitude.

These techniques have been applied to the construction of a number of devices for converting heat at high temperatures directly to electricity. The efficiency of the process has been increasing rapidly: experiments at the General Electric Company, Schenectady, by Dr. V. C. Wilson resulted in efficiencies of 0·5 per cent in January, 1957, 8 per cent in April of the same year and, in common with other devices, have been improved considerably since that date.

Thermionic emission virtually ceases for any surface at temperatures below 500° C, so that the " cold " collecting surface can be allowed to operate at this temperature. Since thermoelectric devices will work at any temperature within the limitations of the materials from which they are made it seems likely that to convert heat at high temperature to electrical energy with the maximum possible efficiency it may well be possible to link the two phenomena in a combined thermionic-thermoelectric generator. In this way full use can be made of the heat available and overall efficiencies of 30 to 40 per cent, or even higher, can be visualised.

It should be stated that the electrical power produced by either thermoelectric or thermionic techniques must always be direct current.

Theoretical Principles

Figure of Merit

Generally, many of the physical properties of materials are determined by the way in which electrons are distributed around the atoms in a crystal lattice. Thus, in a lattice the electrons exist in a number of energy bands, and it is the difference in energy between the valence and conduction states which determines whether the material is a metallic conductor, semiconductor or insulator. In metals this energy difference is zero and the electrons are free to conduct

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electricity or heat through the crystal lattice. In semiconductors the difference ranges from 0·1 to approximately 0·4 electron volts, and electrons can be excited across this gap by thermal or optical excitation. Insulators have much larger gaps, across which the electrons cannot be excited.

When once the electron has entered the conduction band it can take part in electrical conduction. The positively charged hole which it leaves in the lattice can also take part. In most cases, however, the semiconductor contains impurity atoms (10^{16} to 10^{18} per cu. cm), which also contribute to the electrical conductivity. Thus, if they act as substitutional impurities and possess more valence electrons than the parent atoms they usually donate electrons for conduction processes; if less then they provide positive holes.

Heat in metals is also conducted principally by electron movements. In some semiconductors and insulators, however, thermal conduction takes place by vibrations of the atomic lattice, and in many cases practically all the heat is transported by this mechanism.

Many semiconductors possess Seebeck coefficients which are several orders of magnitude greater than those of metals. In 1855 Rayleigh gave an approximate treatment of the efficiency of thermoelectric generators. A more rigorous treatment of thermoelectric generation and cooling was given in 1911 by Altenkirch.[5] This has been modified slightly by many authors but the presentation by Joffe[6] is used here.

The potential performance of the semiconducting materials in any thermoelectric device is governed by a figure of merit, z, for each of the two materials used (see List of Symbols). This can be visualised by the following argument. The greater the value of z the better will be the potential performance of the material in thermoelectric applications since more power will be developed as α increases and less will be dissipated by Joule losses in the thermoelement itself as σ increases and less by thermal conduction from hot to cold junction as K decreases.

Efficiency of Thermoelectric Generation

The efficiency is defined as the ratio of useful electrical energy delivered to an external circuit to the energy consumed from an external heat source. This efficiency is

$$\eta = \frac{T_1 - T_0}{T_1} \cdot \frac{\frac{m}{m+1}}{1 + \frac{m+1}{zT_1} - \frac{T_1 - T_0}{2T_1}\cdot\frac{1}{m+1}} \quad . \quad . \quad . \quad (1)$$

For maximum power transfer into the load $R = r$, therefore $m = 1$, giving

$$\eta = \frac{T_1 - T_0}{T_1} \cdot \frac{1}{2 + \frac{4}{zT_1} - \frac{T_1 - T_0}{2T_1}} \quad . \quad (2)$$

For maximum efficiency, however,

$$\eta = \frac{T_1 - T_0}{T_1} \cdot \frac{M - 1}{M + \frac{T_0}{T_1}} \quad . \quad . \quad (3)$$

where

$$M = \left(\frac{R}{r}\right)_{opt} = \left[1 + \frac{z}{2}(T_1 + T_0)\right]^{\frac{1}{2}} \quad . \quad (4)$$

Fig. 2 shows typical curves of η as a function of m. For low z and low mean temperature

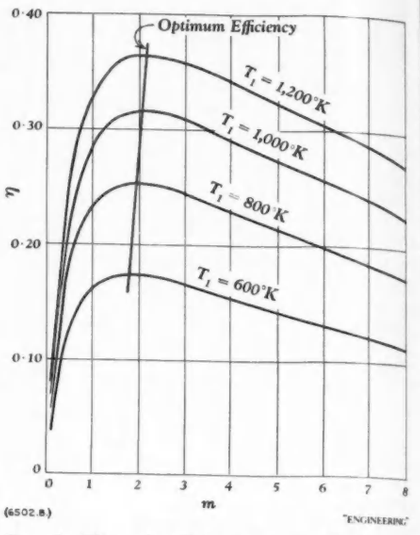


Fig. 2 Thermal efficiency as a function of m and T_1 ($T_0 = 300°K$, $z = 5 \times 10^{-3}$).

the value of M is not very different from unity so that the efficiency of the device when delivering maximum power is not far removed from the optimum. As the efficiency is improved by increasing z and the maximum temperature the two conditions deviate further.

Clearly, the first factor in the expression for efficiency (1) represents the thermodynamic efficiency of a reversible engine (Carnot cycle)

List of Symbols

The solid-state generator is here referred to as a thermoelectric generator or device. The thermionic generator or device is one in which a gaseous phase is present.

Symbol	Description	Units
	Thermoelectric Devices	
E_0	e.m.f. of device on no-load	volt
E	e.m.f. at terminals on load $= E_0 \frac{R}{R+r}$	volt
I	load current	ampere
W	power output = EI	watt
m	ratio of external load resistance R to internal resistance r	
α	Seebeck coefficient of material*	volt per °K
σ	electrical conductivity of material	$ohm^{-1}\ cm^{-1}$
ρ	electrical resistivity of material $= \frac{1}{\sigma}$	ohm cm
K	thermal conductivity of material	watt per cm °K
u	charge mobility of material	sq. cm per sec volt
z	figure of merit $= \frac{\alpha^2\sigma}{K}$ for single material, and $\frac{(\alpha_1 + \alpha_2)^2}{[(K_1\rho_1)^{\frac{1}{2}} + (K_2\rho_2)^{\frac{1}{2}}]^2}$ for a pair of materials (properties denoted by suffixes 1 and 2) forming a thermoelement, provided that the cross-sectional areas, A_1, and A_2, of the materials are in the ratio $\frac{A_1}{A_2} = \left(\frac{\rho_1 K_2}{\rho_2 K_1}\right)^{\frac{1}{2}}$	$°K^{-1}$
N	number of thermoelements in thermopile $= \frac{E_0}{\alpha(T_1 - T_0)}$	
T_1	mean temperature of hot junctions	°K
T_0	mean temperature of cold junctions	°K
η	efficiency of electrical generation $= \frac{T_1 - T_0}{T_1} \times \frac{\frac{m}{m+1}}{1 + \frac{m+1}{zT_1} - \frac{T_1 - T_0}{2T_1}\cdot\frac{1}{m+1}}$	
S	total cross-section of thermopile normal to direction of heat flux	sq. cm
q_h	heat flux at hot junction	
q_c	heat flux at cold junction	watt per sq. cm
q_m	mean heat flux through thermopile	watt per sq. cm
A	cross-section of thermoelement $= \frac{S}{N} = A_1 + A_2$	watt per sq. cm sq. cm
l	effective heat flux path between hot and cold junctions of thermoelement	cm
w	specific power output of thermopile $= \frac{W}{S\,l}$	watt per cu. cm
T_{hi}	inlet temperature of heating fluid	°K
T_{ho}	outlet temperature of heating fluid	°K
T_{hm}	mean temperature of heating fluid $= \frac{T_{hi} + T_{ho}}{2}$	°K
T_{ci}	inlet temperature of cooling fluid	°K
T_{co}	outlet temperature of cooling fluid	°K
T_{cm}	mean temperature of cooling fluid $= \frac{T_{ci} + T_{co}}{2}$	°K
c_h	mean specific heat of heating fluid	joule per gm °K
m_h	mass flow of heating fluid	gm per sec
h_h	heat transfer coefficient at heated surface	watt per sq. cm °K
S_h	effective heat transfer area of heated surface	sq. cm
K_h	effective thermal conductivity of material between heated surface and hot junction	watt per cm °K
l_h	effective heat flux path between heated surface and hot junction	cm
c_c	mean specific heat of cooling fluid	joule per gm °K
m_c	mass flow of cooling fluid	gm per sec
h_c	heat transfer coefficient at cooled surface	watt per sq. cm °K
S_c	effective heat transfer area of cooled surface	sq. cm
k_c	effective thermal conductivity of material between cooled surface and cold junction	watt per cm °K
l_c	effective heat flux path between cooled surface and cold junction	cm
	Thermionic Devices	
y	plate separation of thermionic diode	cm
T_1	cathode temperature	°K
T_2	anode temperature	°K
q_1	heat flux input to cathode	watt per sq. cm
q_2	heat flux removal from anode	watt per sq. cm
q_c	heat flux by conduction	watt per sq. cm
q_r	heat flux by radiation	watt per sq. cm
A	constant in the Richardson equation, governing electron emission from a heated surface	amp per sq. cm °K
J_s	saturation current per unit area of emissive surface	amp per sq. cm
J_0	output current per unit area of emissive surface	amp per sq. cm
K	Boltzmann's constant	$0{\cdot}8612 \times 10^{-4}$eV per °K
V_0	output voltage	volt
ϕ_1	work function of cathode	volt
ϕ_2	work function of anode	volt
δ	space-charge barrier	volt
P_0	power output per unit area of emissive surface	watt per sq. cm
P_1	power loss in electrical leads per unit area of emissive surface	watt per sq. cm

* This property is commonly referred to in the literature as the " thermoelectric power."

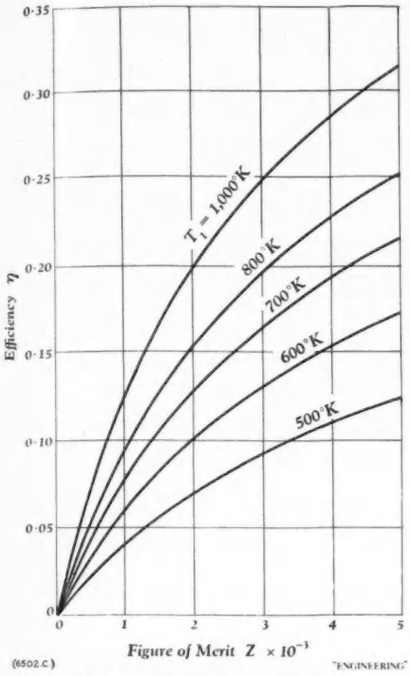


Fig. 3 Efficiency of electrical generation as a function of z at $T_0 = 300°K$.

while the second represents the reduction in this due to Joule heating and heat losses by conduction.

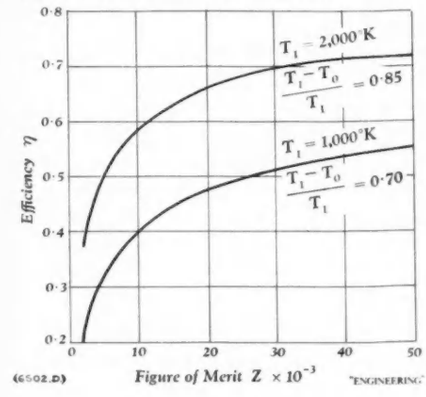
It should be remembered that T_1 and T_0 are the absolute temperatures of the hot and cold junctions respectively and, in any practical generator, involving heat transfer from heating and cooling fluids, these will not be the upper and lower temperature extremities of the cycle. The efficiencies so derived are thus higher than could be realised in practice. Fig. 3 shows such efficiencies as a function of z for a range of T_1 assuming $T_0 = 300°$ K.

The nearness of approach to the Carnot cycle is a function of material properties. Although at present understanding of the factors which govern the relevant properties is somewhat limited, it is possible to conceive substances being developed with different internal structures which attain very high figures of merit and can operate at extremely high temperatures. Fig. 4 shows basic efficiencies as a function of z ($T_1 = 1{,}000°$ and $2{,}000°$ K; $T_0 = 300°$ K).

Thermionic Diode Converter

The possibility of conversion of heat to electricity in a thermionic diode has long been recognised. This arises on account of the small,

Fig. 4 Efficiency of electrical generation for high temperatures and high z at $T_0 = 300°K$.



but finite, emission energies of the electrons from a heated surface, since this energy permits the electrons to flow through a small retarding field.

A number of papers have been written on the subject, among which those of Champeix,[7] Hatsopoules,[8] and Moss [9] attempt a full analysis of the theory of conversion. The treatment given by Hatsopoulos and Kaye[10] is here adopted. This paper reports the work in progress at the Massachusetts Institute of Technology, USA.

Consider two parallel plates of emissive material, placed in a vacuum and separated by a distance y, as shown in Fig. 5. The potential distribution from cathode to anode is illustrated in Fig. 6. The saturation current density of electrons emitted from either cathode of anode in a vacuum is given by Richardson's equation

$$J_s = A\,T^2 e^{-\frac{\phi}{kT}} \quad . \quad . \quad (5)$$

assuming uniform emission.

The fraction of the cathode saturation current which reaches the anode (being the product of the saturation current and that fraction of emitted electrons which have sufficient initial velocities to overcome the retarding potential barrier) can be written as

$$J_{1\text{-}2} = A_1 T_1^2 e^{-\frac{\phi_1}{kT_1}} e^{\frac{[-(\delta + \phi_2 + V_0 - \phi_1)]}{KT_1}}$$
$$= A_1 T_1^2 e^{-\frac{\phi_2}{kT_1}} e^{-\frac{\delta}{KT_1}} e^{-\frac{V_0}{kT_1}} \quad . \quad (6)$$

Similarly, the fraction of the anode saturation current which reaches the cathode is

$$J_{2\text{-}1} = A_2 T_2^2 e^{-\frac{\phi_2}{kT_2}} e^{-\frac{\delta}{kT_2}} \quad . \quad (7)$$

In the devices constructed at MIT the space charge barrier, δ, is removed by the use of very small plate separations, and J_2 is eliminated by choosing a suitably low temperature T_2.

The net current density is thus given by

$$J_0 = A_1 T_1^2 e^{-\frac{\phi_2}{kT_1}} e^{-\frac{V_0}{kT_1}} \quad . \quad (8)$$

The power output per unit area of emissive surface is then given by

$$P_0 = J_0 V_0 - P_1 \quad . \quad . \quad (9)$$

Efficiency of Thermionic Generation

The thermal efficiency of the diode converter can be written as

$$\eta = \frac{(J_0 V_0 - P_1)}{\Sigma q_i} \quad . \quad . \quad (10)$$

where Σq_i represents the sum of all the heat inputs to the cathode, per unit area of emissive surface, required to maintain it at temperature T_1.

For the multiplate design shown in Fig. 7 the total heat inputs to the cathode can be written as

$$\Sigma q_i = J_0 \phi_1 + J_0 (\phi_2 + V_0 + \delta - \phi_1 + 2K T_1) + q_r + q_c \quad . \quad (11)$$

where $J_0 \phi_1$ stands for the heat flux corresponding to the latent heat of evaporation of electrons from the cathodes; $J_0 (\phi_2 + V_0 + \delta - \phi_1 + 2K T_1)$ represents the heat flux corresponding to the kinetic energy of that fraction of electrons which can overcome the retarding potential between cathode and anode; q_r represents the thermal radiation flux between each cathode and the pair of adjacent anodes; q_c represents the thermal conduction flux between each cathode and pair of corresponding anodes due to heat conduction along the necessary electrical leads.

The maximum efficiency so far achieved, with $y = 0{\cdot}001$ in, $T_1 = 1{,}540°$ K, $T_2 = 810°$ K has been about 13 per cent, with an output voltage (single diode) of about 0·7 watt per sq. cm of emissive surface. Hatsopoulos and Kaye conclude that thermal efficiencies greater than 15 per cent may be obtained with a power output of the order of 10 to 30 watts per sq. cm of emissive surface.

The Gas-Filled Diode

Methods other than that of lessening the plate separation have been suggested for reducing or eliminating the space charge barrier, including the use of electric and magnetic fields. One very

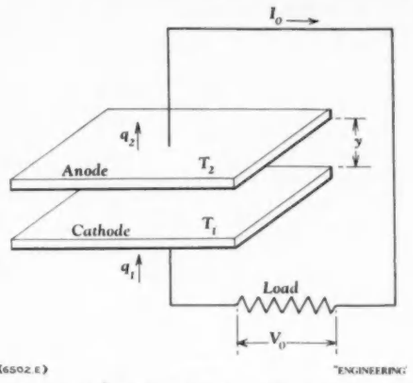


Fig. 5 Thermionic diode converter configuration.

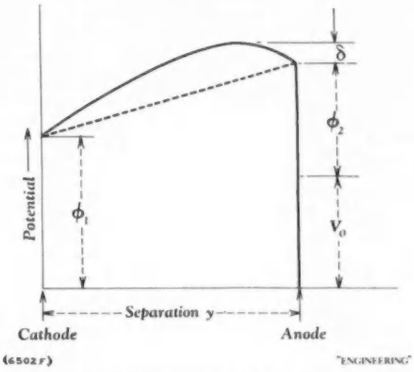


Fig. 6 Potential diagram for diode configuration.

promising technique has been reported recently. Dr. V. C. Wilson, at the GEC Laboratories, Schenechtady, USA, announced that the space charge barrier could be eliminated by the introduction of a small quantity of easily ionised gas into the space separating the electrodes. The addition of the gas changes the characteristics very appreciably, with little effect on the developed voltage. The impedance is lowered by many orders of magnitude, and the device behaves in much the same way as a solid-state thermocouple. It has been described as a plasma thermocouple.

Development on these lines has been carried out at the Los Almos Scientific Laboratory, California, USA, under the auspices of the US Atomic Energy Commission.[11] In preliminary experiments workers claimed a peak power output, using a tantalum emitter and caesium vapour, of 10 watts per sq. cm with a current of approximately 20 amp per sq. cm and an "efficiency" of 5 per cent. There seems no reason to doubt the stated conclusion that the efficiency could be increased very considerably since no attempt was made to limit the losses.

More recently still Los Alamos have announced the manufacture of a prototype reactor fuel element based on this principle. In this device the cathode consists of a rod of enriched uranium in ceramic form, which becomes the high temperature source of electrons when placed in the core of a reactor.

To be continued. References will appear with Part 3.

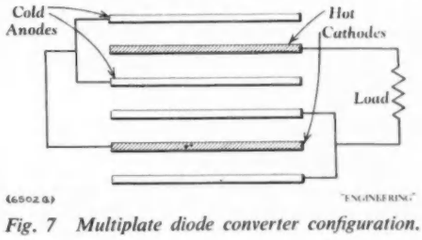


Fig. 7 Multiplate diode converter configuration.

Exhibitions and Conferences

This list, in chronological order, appears in the last issue of each month. Events noticed for the first time and alterations of dates, places, etc., are indicated by an asterisk(*). For details of events not included below, reference should be made to ENGINEERING, *24 April, page 541, and 29 May, page 712. Organisers are invited to send particulars of coming events to the Editor.*

***Research Institute for Management Science, International Seminar.**—Mon., 31 Aug., to Fri., 4 Sept., at Delft. Theme: "Small and Medium-Sized Industries in the European Common Market." Institute's offices: 76 Nieuwe Laan, Delft, The Netherlands.

Crystal Imperfections and the Chemical Reactivity of Solids, General Discussion on.—Wed., 2 Sept., to Fri., 4 Sept., at Queen's University, Kingston, Ont. Apply to Dr. J. A. Morrison, Division of Pure Chemistry, National Research Council, Ottawa 2, Canada; or to the Faraday Society, 6 Gray's Inn Square, London, WC1. Tel. CHAncery 8101.

British Association Meeting.—Wed., 2 Sept., to Wed., 9 Sept., at York. Apply to the secretary, British Association for the Advancement of Science, 18 Adam Street, Adelphi, London, WC2. Tel. TRAfalgar 5733.

St. Erik's Fair, 17th International.—Wed., 2 Sept., to Sun., 13 Sept., in Stockholm. A feature of this year's fair will be the provision of a "closed" section for capital goods, which will not be open to the general public. Offices: 16-18 Lidingövägen, Stockholm 28, Sweden.

Handicrafts and Do-It-Yourself Exhibition, Seventh.—Thurs., 3 Sept., to Sat., 19 Sept., at Olympia, London, W14. Offices: 24 Store Street, London, WC1. Tel. MUSeum 9792.

Scottish Industry Exhibition.—Thurs., 3 Sept., to Sat., 19 Sept., at the Kelvin Hall, Glasgow. Exhibition offices: 2 Woodside Terrace, Glasgow, C3. Tel. Douglas 9911. Information also obtainable from the Scottish Council (Development and Industry), Century Insurance House, King Street, London, SW1. Tel. TRAfalgar 6681.

Quebec Provincial Exhibition.—Fri., 4 Sept., to Sun., 13 Sept., at Exhibition Park, Quebec City. Sponsored by the Provincial Exhibition Organisation, Quebec City, Canada.

***Vienna Autumn Fair.**—Sun., 6 Sept., to Sun., 13 Sept., in Vienna. Apply to the British Austrian Chamber of Commerce, 29 Dorset Square, London, NW1. Tel. PADdington 7646.

Brno Trade Fair.—Sun., 6 Sept., to Sun., 20 Sept., at Brno, Czechoslovakia. Organised by the Chamber of Commerce of Czechoslovakia. Information obtainable from the Auger and Turner Group Ltd., 40 Gerrard Street, London, W1. Tel. GERrard 4951.

MANAGEMENT SCIENCES

***Management Sciences, International Congress.**—Mon., 7 Sept., to Thurs., 10 Sept., at the Conservatoire National des Arts et Métiers, Paris. Organised by the Institute of Management Sciences, 292 Rue Saint-Martin, Paris 3e. Apply to the Service de Presse-Public Relations, 71 Avenue Paul Doumer, Rueil-Malmaison (Seine et Oise), France.

Utrecht Autumn Fair.—*Consumer Goods:* Mon., 7 Sept., to Sat., 12 Sept., at Utrecht, Holland. Apply to Mr. W. Friedhoff, Netherlands Chamber of Commerce, 10 Gloucester Place, London, W1. Tel. WELbeck 9971.

Farnborough Flying Display and Exhibition.—Mon., 7 Sept., to Sun., 13 Sept., at Farnborough, Hampshire. Open to the public on Fri., Sat. and Sun., 11, 12 and 13 Sept., only. Organised by the Society of British Aircraft Constructors, 29 King Street, London, SW1. Tel. TRAfalgar 3231.

Packaging Exhibition, Sixth.—Tues., 8 Sept., to Fri., 18 Sept., at Olympia, London, W14. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

Food, Cooking and Catering Trades Exhibition.—Tues., 8 Sept., to Sat., 19 Sept., at the City Hall, Manchester. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester 3. Tel. Deansgate 6363.

***Aeronautical Research and Development, Advisory Group for (AGARD).**—This body is formed under the auspices of the North Atlantic Treaty Organisation (NATO). Wed., 9 Sept., to Mon., 14 Sept., meeting of Wind Tunnel Panel at Marseilles. Mon., 14 Sept., to Wed., 23 Sept., meetings of various panels on various dates during this period at Aachen, Frankfurt and Wiesbaden, Germany. Apply to AGARD Secretariat, Palais de Chaillot, Paris 16e.

***Statistical Problems, Conference on.**—Fri., 11 Sept., to Sun, 13 Sept., at Loughborough College of Technology, Loughborough. Organised by the Royal Statistical Society, 21 Bentinck Street, London, W1. Tel. WELbeck 7638.

European Machine Tool Exhibition.—Sat., 12 Sept., to Mon., 21 Sept., in Paris. Apply to the Machine Tool Trades Association, Brettenham House, Lancaster Place, London, WC2. Tel. TEMple Bar 3606.

Textile Machinery Exhibition, Third International.—Sat., 12 Sept., Mon., 21 Sept., in Milan. United Kingdom firms should apply to Textile Recorder (Machinery and Accessories), Exhibitions Ltd., Old Colony House, South King Street, Manchester 2.

German Industries Exhibition, Tenth.—Sat., 12 Sept., to Sun., 27 Sept., in Berlin. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, SW1. Tel. WHItehall 8211.

ASTM Third Pacific Area National Meeting.—Week commencing Sun., 13 Sept., at the Sheraton Palace Hotel, San Francisco, Calif., USA. Organised by the American Society for Testing Materials, 1916 Race Street, Philadelphia, Pa., USA.

Treatment of Waste Waters, Symposium on.—Mon., 14 Sept., to Sat., 19 Sept., at King's College, Newcastle upon Tyne. Apply to Mr. Peter C. G. Isaac, Department of Civil Engineering, King's College, University of Durham, Claremont Road, Newcastle upon Tyne 1. Tel. Newcastle 29963.

Agricultural Aviation Conference, International.—Mon., 14 Sept., to Sat., 19 Sept., at Cranfield. Organised by the College of Aeronautics, Cranfield, Beds.

Association of Public Lighting Engineers, Annual Conference.—Tues., 15 Sept., to Fri., 18 Sept., at the Music Hall, Aberdeen. Includes an exhibition of street-lighting equipment and an outdoor display of lamp columns and mobile equipment. Organised by the Association of Public Lighting Engineers, 76 Victoria Street, SW1. Tel. VICtoria 3655.

Industrial Designers, Conference of.—Wed., 16 Sept., o Fri., 18 Sept., in Stockholm. Organised by the International Council of Societies of Industrial Designs (ICSID), Stockholm, Sweden.

STRESS ANALYSIS

Institute of Physics: Stress Analysis Group: Annual Resident Conference.—Wed., 16 Sept., to Fri., 18 Sept., at Birmingham University. Apply to Mr. J. Lawrence, Institute of Physics, 47 Belgrave Square, London, SW1. Tel. BELgravia 6111.

***Royal Meteorological Society, Symposium.**—Thurs., 17 Sept., to Sat., 19 Sept., at the Department of Physics, St. Mary's College, Durham. Society's Offices: 49 Cromwell Road, London, SW7. Tel. KENsington 0730.

Innsbruck Export and Samples Fair.—Sat., 19 Sept., to Sun., 27 Sept., in Innsbruck. Information from British Austrian Chamber of Commerce, 29 Dorset Square, London, NW1. Tel. PADdington 7646.

Preserved Foods and Packaging Exhibition,—14th International.—Sun., 20 Sept., to Wed., 30 Sept., at Parma, Italy. Agents: Italian Chamber of Commerce for Great Britain, 31 Old Burlington Street, London, W1. Tel. REGent 2411.

***Knowing Your Customer: Conference.**—Mon., 21 Sept., at the Royal Festival Hall, Southbank, London, SE1. Organised by the British Institute of Management, 80 Fetter Lane, London, EC4. Tel. HOLborn 3456.

Building Research Studies and Documentation, First Congress of the International Council for (CIB).—Mon., 21 Sept., to Fri., 25 Sept., in Rotterdam. Apply to the secretariat CIB, c/o Bouwcentrum, PO Box. 299, Rotterdam, Netherlands; or to the Building Research Station, Bucknolls Lane, Watford, Herts. Tel. Garston 4040.

Instrument-Automation Conference and Exhibit, 14th.—Mon., 21 Sept., to Fri., 25 Sept., at the International Amphitheatre, Chicago. Organised by the Instrument Society of America, 3443 South Hill Street, Los Angeles 17, Calif., USA.

Institute of Metals, Meeting.—Mon., 21 Sept., to Tues., 29 Sept., in Stockholm and Copenhagen. Institute's offices: 17 Belgrave Square, London, SW1. Tel. BELgravia 3291.

Magnetism, Conference on Some Aspects of.—Tues., 22 Sept., to Thurs., 24 Sept., in Sheffield. Sponsored by the Institute of Physics, 47 Belgrave Square, London, SW1. Tel. BELgravia 6111.

MARKETING

***Marketing Conference.**—Wed., 23 Sept., at 21 Tothill Street, London, SW1. Arranged jointly by the British-Swedish Chamber of Commerce in Sweden, 5B Hovslagargatan, Stockholm C, Sweden, and the Federation of British Industries, 21 Tothill Street, London, SW1. Tel. WHItehall 6711.

250th Anniversary of the Successful Use of Coke in Iron Making.—Wed., 23 Sept., to Fri., 25 Sept., at The University, Birmingham, and at Coalbrookdale, Shropshire. Apply to the Iron and Steel Institute, 4 Grosvenor Gardens, London, SW1. Tel. SLOane 0061.

International Scientific Film Association, 13th Congress.—Wed., 23 Sept., to Fri., 2 Oct., in London and Oxford. Organised by the Scientific Film Association, 3 Belgrave Square, London, SW1. Tel. BELgravia 6188.

***Statistical Methods in Social Investigation, Conference.**—Fri., 25 Sept., to Sun., 27 Sept., at Queen's College, Cambridge. Organised by the Royal Statistical Society, 21 Bentinck Street, London, W1. Tel. WELbeck 7638.

Fisheries Trade Fair, Fourth International.—Fri., 25 Sept., to Sun., 4 Oct., at Copenhagen, Denmark. Agents: John E. Buck and Co., 47 Brewer Street, London, W1. Tel. GERrard 7576.

Perth Royal Agricultural Show.—Sat., 26 Sept., to Fri., 2 Oct., in Perth. Organised by the Royal Agricultural Society, 9 Howard Street, Perth, Western Australia.

Instrument Symposium and Research Equipment Exhibit, Ninth Annual.—Mon., 28 Sept., to Thurs., 1 Oct., at the National Institutes of Health, Bethesda, Maryland, USA. Sponsored by the Washington, DC, sections of various United States organisations, inc. the American Chemical Society and the Instrument Society of America. Apply to Mr. James B. Davis, National Institutes of Health, Bethesda 14, Maryland, USA.

Watch and Jewellery Trade Fair, Fifth International.—Mon., 28 Sept., to Fri., 2 Oct., at the Royal Albert Hall, Kensington Gore, London, SW7. Organised by Trade Fairs and Promotions Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422.

***New Towns Exhibition.**—Fri., 2 Oct., to Sat., 17 Oct., at the Royal Academy, Burlington House, Piccadilly, London, W1. Open to the public on and after 3 Oct. Organised by the Town and Country Planning Association, 28 King Street, London, WC2. Tel. TEMple Bar 5006.

***Swiss Fortnight: Switzerland on Show.**—Mon., 5 Oct., to Sat., 17 Oct., in London and other UK towns. A comprehensive programme of exhibitions and other events has been arranged. Particulars from Preslanders (Public Relations) Ltd., 140 Park Lane, London, W1. Tel. MAYfair 4634; or from the Commercial Attaché, Swiss Embassy, 18 Montagu Place, London, W1. Tel. PADdington 0701.

***Planned Maintenance, Conference on.**—Tues., 6 Oct., at the Livingstone Hall, Broadway, London, SW1. Tickets: one guinea. Organised, in conjunction with the British Productivity Council, by the Harrow and Wembley Productivity Association, Kodak Ltd., Harrow, Middlesex.

***Radio Apprentices' Training, Symposium.**—Wed., 7 Oct., at RAF Station, Locking, near Weston-super-Mare. Arranged by the South Western Section of the British Institution of Radio Engineers, 9 Bedford Square, London, WC1 (Tel. MUSeum 1901) in conjunction with the RAF Radio Apprentices School. Apply to Flt. Lt. D. R. McCall, c/o 27 OMQ, RAF, Locking, Weston-super-Mare.

***Rubber: Industrial Technical Organisation, Conference.**—Fri. and Sat., 9 and 10 Oct., at the Palace Hotel, Southport. Organised by the Institution of the Rubber Industry, 4 Kensington Palace Gardens, London, W8. Tel. BAYswater 9101.

Business Efficiency Exhibition.—Mon., 12 Oct., to Sat., 17 Oct., at King's Hall, Belfast. Organised by Office Appliance and Business Equipment Trade Association, 64 Cannon Street, London, EC4. Tel. CENtral 7771.

***Production Management, Residential Course on.**—Thurs., 15 Oct., to Tues., 20 Oct., at Seabank Hotel, Porthcawl, Wales. Organised by the British Institute of Management, 80 Fetter Lane, London, EC4. Tel. HOLborn 3456.

ENGINEERING INDUSTRIES

Engineering Industries Association's Twelfth Engineering Display.—Tues., 20 Oct., to Thurs., 22 Oct., at the Royal Horticultural Society's new hall, Greycoat Street, London, SW1. Association's offices: 9 Seymour Street, London, W1. Tel. WELbeck 2241.

Motor Exhibition, 44th International.—Wed., 21 Oct. to Sat., 31 Oct., at Earl's Court, London, SW5. Organised by the Society of Motor Manufacturers and Traders Ltd., Forbes House, Halkin Street, London, SW1. Tel. BELgravia 6611.

***Gas-Lubricated Bearings, Symposium.**—Mon., 26 Oct., to Wed., 28 Oct., in Washington, DC, USA. Organised by the Office of Naval Research, US Department of the Navy. Apply to Mr. S. W. Doroff, Power Branch, Office of Naval Research, Washington 25, DC, USA.

***American Concrete Institute, Regional Meeting.**—Mon., 2 Nov., to Thurs., 5 Nov., in Mexico City. Theme: "Concrete Problems and Techniques in Mexico and the South Western United States." Institute offices: P.O. Box 4754, Redford Station, Detroit 19, Mich., USA.

***Combustion Institute, Fall Meeting.**—Mon., 2 Nov., to Thurs., 5 Nov., in Los Angeles. Theme: "Equilibria and Performance of High-Temperature Systems, with Particular Reference to Rocket, Ramjet and Turbojet Systems." Apply to the secretary, Western States Section, Combustion Institute, 16902 Bollinger Drive, Pacific Palisades, Calif., USA.

***Combustion Engineering Association.**—Tues., and Wed., 3 and 4 Nov., at the Royal Hotel, Scarborough. Association's offices: 70 Jermyn Street, London, SW1. Tel. WHItehall 5536.

***Canadian National Packaging Exhibition.**—Tues., 3 Nov., to Thurs., 5 Nov., in the Automotive Building, Exhibition Grounds, Toronto. Sponsored by the Packaging Association of Canada, 1 St. Claire Avenue W., Toronto 7, Canada.

Industrial Efficiency and Safety Exhibition.—Tues., 3 Nov., to Sat., 14 Nov., at the City Hall, Deansgate, Manchester 3. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

Automation Congress and Exposition, Fifth International; and Second Military Automation Show.—Mon., 16 Nov., to Fri., 20 Nov., at the New York Trade Show Building, New York. Organised by Richard Rimbach Associates, 846 Ridge Avenue, Pittsburgh 12, Pa., USA.

***British Institute of Management, National Conference.**—Tues., 17 Nov., to Thurs., 19 Nov., at Harrogate. Institute's offices: 80 Fetter Lane, London, EC4. Tel. HOLborn 3456.

***Radio Hobbies Exhibition, International.**—Wed., 25 Nov., to Sat., 28 Nov., at the Royal Horticultural Society's Old Hall, Vincent Square, London, SW1. Held under the auspices of the Radio Society of Great Britain. Exhibition manager: Mr. P. A. Thorogood, 35 Gibbs Avenue, Edgware, Middlesex. Tel. MUSeum 3450.

***Institute of Marine Engineers, Conversazione.**—Fri., 4 Dec., at Grosvenor House, London, W1. Institute's offices: Memorial Building, 76 Mark Lane, London, EC3. Tel. ROYal 8493.

"Model Engineer" Exhibition.—Wed., 30 Dec., to Sat., 9 Jan., 1960, at the Royal Horticultural Society's new hall, Greycoat Street, London, SW1. Organised by The Model Engineer (Percival Marshall and Co., Ltd.), 19-20 Noel Street, London, W1. Tel. GERrard 8811.

***Recent Mechanical Engineering Developments in Automatic Control, Symposium.**—Tues., 5 Jan., to Thurs., 7 Jan., 1960, at 1 Birdcage Walk, London, SW1. Organised by the Institution of Mechanical Engineers, 1 Birdcage Walk, St. James's Park, London, SW1. Tel. WHItehall 7476.

***Electronics, Sixth National Symposium on Reliability and Quality Control in.**—Mon., 11 Jan., to Wed., 13 Jan., 1960, at the Statler Hilton Hotel, Washington, DC, USA. Information obtainable from Mr. R. Brewer, Research Laboratories, General Electric Co., Ltd., Wembley, Middlesex. Tel. Arnold 1262.

Cleaning and Maintenance and Floor Trades Exhibition and Convention, First.—Mon., 1 Feb., to Fri., 5 Feb., 1960, Royal Horticultural Society's old hall, Vincent Square, London, SW1. Organised by Contemporary Exhibitions Ltd., 40 Gerrard Street, London, W1. Tel. GERrard 4951.

BRITISH TOY FAIR

British Toy Fair.—Mon., 15 Feb., to Fri., 19 Feb., 1960, at Brighton. Organised by the British Toy Manufacturers' Association, 93-94 Hatton Garden, London, EC1. Tel. CHAncery 9158.

Engineering Materials and Design Exhibition and Conference, First.—Mon., 22 Feb., to Fri., 26 Feb., 1960, at Earl's Court, London, SW5. Organised by Industrial and Trade Fairs Ltd., Drury House, Russell Street, London, WC2. Tel. TEMple Bar 3422.

***Scientific Management, 12th International Congress of the International Committee of (COS).**—Mon., 22 Feb., to Fri., 4 Mar., 1960, in Sydney and Melbourne, Australia. Organised by the Australian Institute of Management. Inquiries in the United Kingdom should be addressed to the Regional and Overseas Department, British Institute of Management, 80 Fetter Lane, London, EC4. Tel. HOLborn 3456.

***Fire Protection Conference, National.**—Thurs. and Fri., 25 and 26 Feb., 1960, at the Connaught Rooms, Great Queen Street, London, WC2. Arranged, with the support of the Home Office and the Ministry of Labour and National Service, by the Fire Offices' Committee Fire Protection Association, 31-45 Gresham Street, London, EC2. Tel. MONarch 7412.

***Leipzig Spring Fair.**—Sun., 28 Feb., to Tues., 8 Mar., 1960, at Leipzig. Consumer goods and technical and capital equipment. Fair offices: Postschliessfach 329, Leipzig C1, Germany. Agents: Leipzig Fair Agency, 39 St. James's Place, London, SW1. Tel. HYDe Park 3111.

***Manned Space Stations, Symposium on.**—In April, 1960, at the Ambassador Hotel, Los Angeles, Calif., USA. Organised by the Institute of Aeronautical Sciencies, 2 East 64th Street, New York 21.

Electrical Engineers Exhibition, Ninth.—Tues., 5 April, to Sat., 9 April, 1960, at Earl's Court, London, SW5. Sponsored by the Association of Supervising Electrical Engineers, 23 Bloomsbury Square, London, WC1. (Tel. LANgham 5927); and organised by Electrical Engineers (ASEE) Exhibition Ltd. 6 Museum House, 25 Museum Street, London, WC1. Tel. MUSeum 3450.

***Osaka International Trade Fair, Fourth.**—Sat., 9 April, to Tues., 26 April, 1960, in Osaka. Offices: Honmachibashi Hiagashi-ku, Osaka, Japan.

***Compressed Air and Hydraulics Exhibition, International.**—Mon., 25 April, to Fri., 29 April, 1960, at Olympia, London, W14. Organised by *Compressed Air and Hydraulics*, St. Richard's House, Eversholt Street, London, NW1. Tel. EUSton 7293.

***Office Management, International Conference.**—In May, 1960, at Montreal, Canada. Organised by the National Office Management Association. Apply to the Field Service Division, NOMA, 1931 Old York Road, Willow Grove, Penn., USA.

***Kemp's Television Production Exhibition.**—Mon., 9 May, to Fri., 13 May, 1960, at Alexandra Palace, Wood Green, London, N22. Apply to the general manager, Kemp's Commercial Guides Ltd., 299-301 Gray's Inn Rd, London, WC1. Tel. TERminus 0152.

On the Shelf

By Frank H. Smith

The Production Engineering Research Association (Melton Mowbray, Leicestershire) announce some cover-to-cover translations. This immediately makes everybody think it must be Russian, of course, and everybody is quite right. Funny how this cover-to-cover business has only the one language associated with it. Anyway, the two journals for which PERA are making themselves responsible are *Russian Engineering Journal* and *Machines and Tooling*. The basic (home) rate for the first is £8 (12 issues) with variations for abroad, libraries home and away, and single copies. The other comes out at £3 10*s*, basic but full details of rates can, of course, be obtained from PERA in the pie country. Or should I say huntin'?

BS 2509 at 6*s* comes from the British Standards Institution (2 Park Street, London, W1) and deals with " British Standard for Periodicals of Reference Value: Form and Presentation." I hope I've put that colon in the correct place because BSI have implied a pause by starting a fresh line. This replaces the 1954 " Layout of Periodicals," in the title of which " layout was considered to have too strong a typographical implication to describe the content of this standard. . . ." The text runs from pages 6 to 16 and from this the publishers have contrived to get a 286 item index! It might be easier to learn it by heart. Nevertheless, this is a most valuable standard and, if it is adhered to, the librarians' and the students' lives will be made considerably easier. With such an index it would be foolish to pick out any particular clause but a casual glance reveals an attempt to regularise such constant inconsistencies as position of contents list, spine-titles, adequate margins for binding, title-page details, and so on.

It is refreshing to read a latest-developments bulletin that seems to have no axe to grind. *Industrial Research Newsletter*, from Armour Research Foundation of Illinois Institute of Technology, Chicago 16 (news of organised scientific research and development reported briefly and factually as a service to industry) makes a pleasant and interesting change. Our own General Electric (as opposed to that of America) gets a paragraph for developing an electronic hearing device for detecting miners' distress signals through rock. Another item is an odourless deodorant which instead of counteracting the bad smell or deadening your sniffer, absorbs the pong.

Then the *other* GEC is building a " literature searching computer " which can whip through 100,000 abstracts an hour as against the modest 30 which the present machine can manage. In six minutes this new GE-250 can search the world's metallurgical literature for one year. This, of course, is a Bad Thing because it will encourage people to write more in the hope of giving the GE-250 indigestion.

A brightly coloured cover adorns No. 1 of ICI (with the funny little double wiggle under it) *Plastics Today*. Only 16 pages, this is pretty intensively ICI plastics but it does digress a little to talk about the electron microscope. An interesting list at the end gives 23 trade names and what they are applied to.

D. Van Nostrand of 358 Kensington High Street, London, W14 (who also " do " Elsevier books here) have some noteworthy titles for the end of August. J. N. Shive is the author of *Properties, Physics and Design of Semiconductor Devices* (*not* pint-size ticket punching machines) at 73*s*; *Control Engineering*, by G. J. Murphy at 56*s*; and *Introduction to Mathematical Physics*, by W. Nand at 54*s* 6*d*. But why should I go on wasting space? Drop a line to D. Van N. asking for their " Postal Traveller " and they'll throw in titles on carpet laying (this should make any chicken jealous) and how to make money from your greenhouse (smash all the glass and claim on a sound-barrier penetrator).

LITTLE GO

Scale-Up in Practice. Edited by RICHARD FLEMING. *Reinhold Publishing Corporation, 430 Park Avenue, New York 22, NY, USA*; and *Chapman and Hall Limited, 37 Essex Street, London, WC2.* (36*s*)

If an engineering investigation can be made on a small scale, it will frequently be much cheaper than tests with full size machinery, since the machine itself will weigh less and will be cheaper to construct (provided that too small a scale is not chosen), supplies and services will be more easily provided, less raw materials will be required, and less defective product will have to be disposed of. When theoretical knowledge is complete, everything is known about a machine, and its behaviour can be completely expressed in mathematical terms, there is no need to investigate its behaviour and certainly no need for model experiments. But such a happy state of affairs is rare and there are usually more problems urgently needing investigation than there are people or time to do the work or money to pay for it. Sometimes then small-scale work can be most attractive.

The method of dimensions shows that even when the mathematical relations which express the behaviour of the machine are not known, the physical quantities involved can be formed into dimensionless groups and provided that these groups can be kept constant, the model should behave in the same way as the full-scale equipment.

Small-scale testing has been brilliantly exploited in flow trials where the Reynolds and Froude numbers rule, for example in wind tunnels and the tank testing of ships, but in some other branches of physics the relations between model and full size are sometimes practically impossible to use. One example is the study of the dynamic behaviour of building structures, where the model, in order to have the required values of Young's modulus and density, would have to be made of such an unconvincing material as loaded wax.

This book is a collection of papers presented to a meeting held in Philadelphia in April of last year under the auspices of the American Institute of Chemical Engineers and the local university, and deals solely with the problems of pilot plants in chemical manufacture. The papers are very uneven in content and quality. The first and fourth deal with the practical selection of pilot plant size, the pitfalls which one may find in interpreting the results of pilot plant working, and some interesting examples of unexpected information, for example how continuously recirculated reagents may build up impurities which are catalyst poisons. The third paper deals at a somewhat elementary level with the application of analogue computers to plant design. The last three papers are concerned more with the economics of plant location and size as affecting the selling price of a product and the possible demand, rather than with the design and running of pilot plants.

To the reviewer, the " meat " of the book lies in the 32 page paper by Metzner and Pigford, who, starting at the beginning with dimensional analysis, develop some of the more important dimensionless groups, show which of these offer reasonable service from models, and finish by showing how chemical kinetics affect model work for first and second order reactions.

It is somewhat surprising that none of the contributors deal with the application of instrumentation to pilot plants since this is a field where recent developments make calculations to full size plant reasonably dependable.

It is with somewhat of a shock that one learns that this book of 134 pages, 7¼ in by 5 in, of competent but not outstanding typography in a somewhat gaudy cloth binding, should be priced at 36*s*.

G. MORRIS

RECOGNISING NOISE

Nonlinear Problems in Random Theory. By NORBERT WIENER. Technology Press Research Monographs. *The Technology Press of Massachusetts Institute of Technology; John Wiley and Sons Incorporated, 440 Fourth Avenue, New York 16, NY, USA*; and *Chapman and Hall Limited, 37 Essex Street, London, WC2.* (36*s*)

More and more, as the frontiers of knowledge are advanced, are we being made aware of randomness in the universe. Sooner or later, in problems ranging from astronomy to anthropology, we come across fundamental difficulties in taking a measurement because of the " noise " which is obscuring our view of the truth. Ingenious devices such as Masers only delay the time when we have to accept that noise is present in our measurements and that the best way to deal with the situation is to develop a random noise theory.

Almost by definition exact treatises on random theory are few and far between, so that Chapman and Hall are to be congratulated on publishing three works on the subject in the past year. Their latest publication on this subject *Nonlinear Problems in Random Theory* has been written by Professor Wiener of the Massachusetts Institute of Technology and, in view of the author's previous work on prediction, one approaches this new work with an eager expectancy. Unfortunately to travel hopefully is so often better than to arrive and one's enthusiasm tends to wane when confronted with the thickets of integral signs in the first chapters of the book, which are a transcript of a series of lectures given by Professor Wiener to a selected group of advanced students at MIT. The informality of the style is stimulating, but one of the disadvantages of this method is that what is probably just difficult mathematics to the listener who is familiar with the author's notation and way of thinking, is almost impossible to the remote reader, especially since some symbols are introduced without definition.

With the increasing complexity of modern scientific experiments, which are very often designed to investigate phenomena at the very limits of measurement, it is becoming difficult for the experimenter to be so completely familiar with the apparatus that he is able to distinguish artefact from the required measure. This applies in mathematics as much as in any other science and before any application of mathematical theory, it is essential for the arguments and assumptions that have been made during the development of the theory to be completely understood. Unless they are, there is a constant danger that an assumption made or a restriction imposed will invalidate the application of the theory to a particular problem. This imposes upon the author of a book the obligation to explain each step, restriction and assumption very clearly and in language simple enough for readers from other branches of science to be able to determine whether the theory can be applied to their problems. This Professor Wiener does not do.

The basic premise is that in Brownian movement (when considered in one dimension only) the amount of departure from a given position during an interval of time has a Gaussian distribution. This premise has been used by other

writers in the past. Professor Wiener goes on to develop a general function giving the probability of finding a particle in a particular place at a particular time. For ease of manipulation when dealing with non-linear applications of the theory, this stochastic function is then expressed in terms of orthogonal functionals similar to the use of orthogonal polynomials in curve fitting.

After this impressive piece of mathematics, Professor Wiener goes on to consider some practical applications of the general theory and here his choice of examples is not good. In particular, the spectrum of the brain waves which he gives as experimental fact is incorrect and this invalidates his conjecture about the nature of the alpha rhythm. Even if the spectrum were as shown, the solution arrived at is certainly not the only one which will explain the frequency distribution.

This and the other applications are ideas which can usefully be aired at seminars, but if given the authority of print, can be misleading. They should be treated as mathematical exercises and as such may be stimulating but they are not explanatory.

The index is good, but of the nine references quoted, only two are readily accessible; three are unpublished, and the rest are internal reports. The book is a valuable addition to the theory of noise but it should be treated as an advanced work useful only to readers who are highly qualified in mathematics and who already possess considerable knowledge of the subject.

R. COOPER

The Reviewers

Dr. G. Morris is in charge of instrument research in the Nobel Division of Imperial Chemical Industries Limited. He is particularly interested in instrumentation and explosives with special reference to electrostatics, ground vibrations and reliability theory. He is a B.Sc. of London University and a Ph.D.

Dr. R. Cooper is engaged in medical physics studies at the Burden Neurological Institute, and is particularly concerned with physical aspects of electro-encephalography and physiology. Previously he had radar experience in the armed forces, and is a B.Sc., a Ph.D. (in physics), a fellow of the Royal Astronomical Society, and an associate of the Institute of Physics.

Mr. Walter K. Subak, Dipl. Ing., A.M.I.E.E., is a consultant in electrical engineering.

POINTS ON RECORD

Registrierinstrumente. By ALBERT PALM, H. ROTH and E. G. SCHLOSSER. Second Edition. *Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf, Germany.* (27 *DM*)

Recording instruments are used more and more in industry to control production. In addition, they are also used in the laboratory, to provide documentary evidence of processes which are either too fast or too slow for human observation. Among many other considerations in the use of recording instruments is the elimination of human error, and dispensing with personnel in obtaining a curve or diagram representing a continuous line of values. The authors have undertaken the task of making a methodical survey of recording instruments for those unfamiliar with the subject. To do this, they had to contact manufacturers in France, Germany, Great Britain and the United States, to obtain lists and details of their various products.

The first chapter is a detailed summary of the methods used in making recordings. They range from pen and ink, and similar means, to electronic rays. This is developed in the following chapter to cover the mechanical and electrical means of controlling the movement and speed of the recording paper. Chapter three describes the transmission of measured physical values, i.e. forces, paths, and the utilisation of diagrams.

The body of the book is devoted to a description of numerous recording instruments. These include exhaustive details of instruments—with mechanical measuring parts—for recording flows, quantities, paths, forces and temperatures. There are also details of multi-recording units, followed by a description of instruments for electrical measurements.

A final section gives details of the electrocardiograph, and is followed by a series of photographs of recording units used in industry. Among these are pictures of a control board of a high-voltage plant, a turbo-generator, a blast furnace, and diagrams showing speed, locomotive output and energy consumed for part of a railway in Switzerland and Czechoslovakia.

The style of the book is clear, and not difficult for a person with some technical knowledge. There are 200 illustrations of essential working parts of recording instruments, typical recorded graphs, and pictures of recording apparatus. There is also an adequate index.

In conclusion, it should be said that an admirable effort has been made to show the many sided, and most useful applications of recording instruments. It is not surprising to find that the book is already in its second edition.

WALTER K. SUBAK

NEW BOOKS

1959 Clean Air Year Book. *National Society for Clean Air, Palace Chambers, Bridge Street, London, SW1.* (2*s*)

A hotchpotchish 64-page booklet of great interest to cleanairophils. Contains such items as " History of Air Pollution ", " Major Smog Disasters " talking points, a list of recent papers and an outline of the law relating to air pollution.

Definitions and Formulae for Students of Engineering Science. *Sir Isaac Pitman and Sons Limited, Pitman House, Parker Street, Kingsway, London, WC2.* (2*s*)

A neat little pocket book containing definitions, formulae, mechanics, heat, light, sound and electricity and magnetism.

Concrete Practice Volume I. By R. H. ELVERY. *Contractor's Record Limited, Lennox House, Norfolk Street, London, WC2.* (28*s*)

Based on the grade I course of the City and Guilds in concrete practice this is intended primarily for beginners. Goes into fundamentals in some detail.

Reactions Between Aggregates and Cement. Part V: Alkali-Aggregate Interaction: Other Test Criteria. Part VI: Alkali-Aggregate Interaction: Test Procedures. By F. E. JONES and E. D. TARLETON. National Building Studies Research Paper No. 25. Published for the *Building Research Station, Department of Scientific and Industrial Research* by *Her Majesty's Stationery Office, York House, Kingsway, London, WC2.* (4*s* 6*d*)

Part V deals with effects of expansive reaction on bending strength of mortar bars and with development of gelatinous reaction products and cracking. Part VI supplements Part I (Research Paper 14) on tests for reactivity and their difference from those given in the USA.

Plane and Geodetic Surveying for Engineers. Vol. 1: Plane Surveying. By DAVID CLARK. Fifth Edition revised and enlarged by JAMES CLENDINNING. *Constable and Company Limited, 10 Orange Street, London, WC2.* (32*s* 6*d*)

Since the first edition in 1923 " Clark " has been a classic textbook. Volume I now runs to 673 pages. As in the case of the fourth edition most of the new matter has been written in the form of appendices.

Fundamentals of Radio and Electronics. Edited by W. L. EVERITT. 2nd Edition. *Constable and Company Limited, 10 Orange Street, London, WC2.* (57*s* 6*d*)

The first edition (1942) is long outdated. Television, transistor and radar developments have been included besides the revision of basic radio material.

The Design and Use of Instruments and Accurate Mechanism. By T. N. WHITEHEAD. *Dover Publications Incorporated, New York, USA;* and *Constable and Company Limited, 10 Orange Street, London, WC2.* (16*s*)

A reprint (1954) with minor corrections of an American 1933 book. Its reasonable price may compensate its age.

Jigs, Tools and Fixtures. By PHILIP GATES. Fifth Edition Revised. *The Technical Press Limited, 1 Justice Walk, Chelsea, London, SW3.* (30*s*)

The subtitle—" their drawing and design "—indicates the object of this book. There are 27 plates nearly all of which bear a manufacturer's name, and over 170 figures of machine drawing.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Machine Tools

Toolroom Lathe. KERRY'S (ENGINEERING) CO. LTD., Warton Road, Stratford, London, E15. Toolroom lathe with precision ground bed and slides; 11 in swing, all-geared head. Four models with straight or gap bed and 23 in or 40 in between centres. Descriptive booklet.

Plate Bending. HUGH SMITH AND CO. (POSSIL) LTD., Possil Engine Works, Glasgow, N1. Vertical hydraulic presses for plate bending, 3,000 ton loading; capacity for plates up to 10 ft by 2½ in. Leaflet.

Thread Rolling. W. H. A. ROBERTSON & CO., LTD., Lynton Works, Bedford. Flat and circular thread rolling dies for all types of machines and for all standard threads. A " Guide " series booklet.

Cylindrical Grinder. A. A. JONES AND SHIPMAN LTD., Narborough Road South, Leicester. Model 1212 high precision cylindrical grinding machine; roundness accuracy down to 0·00001 in; 4 in swing over table, 12 in between centres. Leaflet.

Shearing Machines. THOS. WARD LTD., Albion Works, Sheffield. The Ficep range of shearing machines, hand and power operated. Capacities up to 6⅞ in round bar. Range includes several types. Leaflets.

Taps and Dies. E. P. BARRUS LTD., 12-16 Brunel Road, London W3. " Greenfield " taps, dies, screw plates, reamers, burrs, etc. Catalogue includes notes on cutting fluids and speeds.

Twist Drills. CLARKSON (ENGINEERS) LTD., Nuneaton. Parallel and taper shank twist drills made from high speed steel to BS 328/1950. Number, letter, and fraction sizes from No. 80 to 4 in dia. Catalogue.

Production Grinder. A. A. JONES AND SHIPMAN LTD., Narborough Road South, Leicester. Model 1049 cylindrical grinder for fast production work with toolroom accuracy. Swing 10 in dia., length of work 18 in. List 253.

Bench Lathe. OLDFIELD AND SCHOFIELD CO., LTD., Halifax. The model ND 21 in and 25 in swing lathe; all-gear headstock, power traverse; will cut threads up to 8 in lead. Folder.

Gear Testing. J. GOULDER & SONS LTD., Kirkheaton, Huddersfield. Machines for testing and measuring gear tooth sizes and profiles; involute, leads and rolling tests. Leaflet.

Shears. CINCINNATI SHAPER CO. LTD., Peel Park Place, East Kilbride, Glasgow. British built Cincinnati guillotine shears with capacities from 4 ft by 12 gauge up to 18 ft by ½ in. Catalogue.

Sheet Metal Machines. THE PRESS AND SHEAR CO. LTD., 172-178 Victoria Road, Acton, London, W3. A range of sheet metal and tube working machines: presses, spinning lathes, shears, rolls, etc. Leaflet gives list.

Vertical Mill. JAMES ARCHDALE & CO. LTD., Blackpole Works, Worcester. No. 2 high speed vertical milling machine; capacity generally in the range of ⅛ in dia. slot drills to 7 in dia. tungsten carbide cutters; spindle speeds up to 3,000 r.p.m. Leaflet.

ENGINEERING PLASTICS HAVE MANY FACES

New and Varied at Olympia 1959

Plastics are here to stay. If you still talk of "plastic" as one material, think again; there are many kinds, some brittle, some cheap, some for high temperatures, and some perhaps expensive; but they are here, waiting for you—the engineer, to try them. They will not be the solution to all problems, but are nevertheless worth investigating, worth learning more about. Olympia in June was busy—with the International Plastics Exhibition. The atmosphere was remarkable, not only because the new products were well received, but because consumers were considering not why they could not use plastics, but why they should. Here are some of the new ones.

FIREPROOF POLYESTERS

Lack of fire resistance has been one big obstacle against extended use of polyester glass laminates. Resins based on Het acid, however, have built-in flame resistance resulting from the 50 per cent proportion of chlorine in the molecule. Het acid was developed in the United States and is now being sold in Europe, together with derived resins, under an exclusive licence held by Albright and Wilson, 1 Knightsbridge Green, London, SW1. Hetron resins had captured 10 per cent of the total American polyester market in 1958 and they figure widely in United States army specifications. One primary aim of their introduction into this country is to widen the field of polyester glass building laminates which are permitted by the insurance companies to be used without special fire sprinkler systems.

POLYPROPYLENE

The discovery that propylene could be polymerised into a useful plastic followed development by Ziegler, of catalysts which create what are called isotactic polymers, that is, ones which are crystalline and ordered, instead of random chains. The illustration below, borrowed from an article by staff of the American General Electric Company, shows the "order" in the isotactic polypropylene molecule. Natta and the Montecatini Chemical Company in Italy developed the material. ICI, Millbank, London, SW1, and Courtauld's, St. Martins-le-Grand, are the two British companies making it in the UK.

ICI's name for the material is Propathene, but Courtauld's extruded sheets and sections are as yet unnamed. With a melting point of 165 to 170° C and a heat distortion temperature of 105° C under a pressure of 66 lb per sq. in it is seen to retain strength in boiling water—one better than polyethylene.

POLYSTYRENES

Manufactured by Distrene, and marketed by British Resin Products, Devonshire House, Piccadilly, London, W1, are two new polystyrene materials—Styron 700 and Styron 440. Both are heat resistant, with distortion temperatures of 106° C and 98° C respectively. The latter of these, 440, is a high impact grade.

STYRENE ACRYLONITRILE COPOLYMERS

From the same manufacturers as the Styrons, but this time a copolymer of styrene and acrylonitrile comes Tyril 767. It possesses an "excellent balance of physical properties" and is suited for applications which require the transparency of general purpose polystyrenes and the toughness of high impact grades: end uses include bristles and fan blades. Tyril 767 is said to be resistant to a wide range of chemicals including aliphatic hydrocarbons and aromatic petrols at normal temperatures.

HIGH IMPACT COPOLYMERS

Anchor Chemical Company, of Manchester 11, showed a copolymer with three constituents—styrene, acrylonitrile and butadiene, which is made in the United States and distributed by Anchor under the name of Cycolac. It is typical of the product of research aimed at increasing the impact resistance of polystyrenes while yet retaining the glossy surface and good chemical resistance, mechanical and physical properties of the single polymer.

Note that copolymers are made by mixing the constituent monomers *before* polymerisation, and that they have a different structure from those in which the polymers are mixed *after* polymerisation.

Reverting to Cycolac, there are five grades with heat distortion points at 264 lb per sq. in of 75 to 100° C. The brittle point of the low temperature grade is − 57° C.

NITRILE RUBBER PLASTICISER

For the formulation of oil resistant nitrile rubbers with low modulus and good low temperature properties, A. Boake, Roberts and Company have introduced a new plasticiser. Called ECP27, it is described as a modified epoxidised oil. It is equally effective with rubbers of high or low acrylonitrile content and is often better than TTP or DOP plasticisers. Some swelling occurs in petroleum solvents, similar to those with TTP or DOP formulations, but the plasticiser extraction is virtually nil, so that rubbers dry out to their original state. Because of its compatability with pvc, the plasticiser appears promising for nitrile rubber—pvc blends used for cable sheathing and conveyor belts. The company's address is Stratford, London, E15.

FILM AND COATING CHEMICAL

Sucrose acetate isobutyrate, SAIB, is a versatile new molecule with a very compact structure. Like other chemicals used for extending and plasticising, it is seldom used alone, but in formulations: even on such a score, however, it looks promising. Its viscosity is low both in and out of solution in other plastics, elastomers, oils and waxes, with which, incidentally, it is remarkably compatible. As a lacquer modifier it permits greater coverage per gallon, and with its low volatility it is not lost from hot mixes (1 per cent in 24 hours at 350° F would be typical): further to this the intrinsic colour is very low. Kodak Limited of Beech Street, London, EC1, are handling SAIB for the makers, Eastman Kodak in the United States.

NEEDLED GLASS MAT

At this stage in the resumé of new materials, the reinforced plastics take over. You have probably heard of glass chopped roving, glass flocks, fabrics, mats and chemically bonded strand mats, but what about mechanically bound chopped strand mat? "Thunderbird" guided weapons are covered with it—much to the satisfaction of Turner Brothers Asbestos of Rochdale. As an introduction, Duramat, as it is called, is made by needling 2 in rovings into glass tissue to give a reinforcing medium which "drapes" well. Moreover it does not "wash." Standard weights are from 1 to 4 oz per sq. ft in widths of 36 in. Two qualities are made—one pretreated for use with polyesters, phenolic and epoxy resins, the other for polyesters only.

INSULATOR MATERIAL

The story of Rosite goes back to 1927, when in Indiana, USA, a new material was introduced called "Rostone." Subsequently it was called Rosite, under which name it established a reputation for being an arc proof, non-carbonising material, capable of being moulded accurately to complex shapes: its main outlet therefore—the electrical industries for switchgear and insulators. It was not until 1957 that production began in Swindon, Britain, but here it now is. Rosite is cold-moulded and dried out, a process which allows tolerances of $\pm 0{\cdot}003$ to $\pm 0{\cdot}005$ in per in to be maintained. With a reasonable impact strength of 0·093 ft lb to B.S. 771 : 1954, it has a dry waxed volume resistivity of $0{\cdot}32 \times 10^{14}$ ohm-cm and an arc resistance at 47·5 volts, 10 amps of 25 seconds.

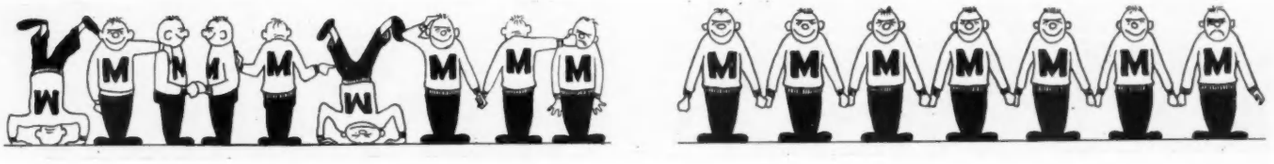
ELECTRICAL DOUGH

The newer approach to electrical moulding materials is typified by the Bakelite glass-fibre and mineral filled polyester doughs, among which DX18927 was shown at the exhibition. Moulding shrinkage is 0·003 to 0·005 in per in; the impact strength is high—2·5 to 4·0 ft lb (B.S. 771 : 1954), and the volume resistivity at 20° C is greater than 10^{14} ohm-cm. After 14 days at 180° C such mouldings shrink about a further 0·004 in per in. To their credit a curing time of 5 minutes at 150° C suffices for sections ½ in thick without the need for breathing.

PREIMPREGNATES

Many drawbacks to the art of hand lay-up of reinforced plastics are overcome by the use of preimpregnated materials: the two most obvious forms in which they come are "doughs" for mouldings with variable cross sections, and sheets. Aeroplastics Limited, a subsidiary of Fairey Aviation, are now producing a range of the latter under a licence from US Polymeric Chemicals. At Hillington, Glasgow, these Aerogreg preimpregnates are being made with glass and synthetic fibre reinforcements, combined with polyester and epoxy resins. The use of silicone and phenolic resins is being developed.

American GEC have illustrated the distinction between ordered and disordered polymers by these two chains of "molecules". Polypropylene is one of the ordered—or isotactic—polymers.



Continuing

ENGINEERING PLASTICS

PHENOLIC FOAM

By "foam" is meant a material in which a proportion of the cells are interconnected. Bakelite Limited of Grosvenor Gardens, London, SW1, make a range based on phenol formaldehyde, and the structural grade, with a density of 4 to 4½ lb per cu. ft, has a compressive strength of 40 lb per sq. in. Its low thermal conductivity of 0·28 Btu per sq. ft per hr per °F per in (BS 874:1956) recommends it for structural insulation, but its cost should be investigated. Phenolic foams can be used up to 130° C and are self-extinguishing. At the exhibition, they were shown in the form of building slabs with reinforced polyester on one side and melamine decorative laminate on the other.

EXPANDED PVC

Plasticell, marketed by Microcell Limited, 9 Kingsway, London, WC2, is a closed cell cellular plastic, available in both rigid and flexible form. Its prime virtue is high strength to weight: for instance, the grade whose density is 2·5 lb per cu. ft has a minimum compressive strength of 40 lb per sq. in. Fig. 1 shows its use in a sandwich construction in bulkhead fittings for the Bristol Britannia airliner. Pretty

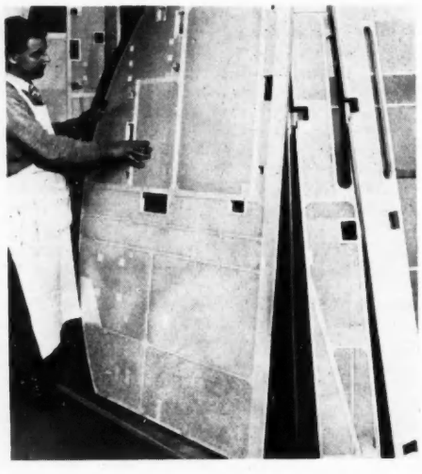


Fig. 1 Closed cell foams are approved for ships bouyancy.

well anything may be stuck to it to form a sandwich laminate. Owing to the closed cell structure of Plasticell it does not absorb water and hence is ideal for buoyancy applications; it is, in fact, approved by the Ministry of Transport and Civil Aviation for use as solid buoyancy in ships' lifeboats.

FOAM FILTER MATERIAL

A new foamed high density polyethylene material is called Vyon, and is made by a sintering process. The makers, Pritchett and Gold and EPS, Dagenham Dock, Essex, developed it as an alternative to Porvic foamed pvc, but because of its similar cost it will not replace this established material in batteries. Instead it appears admirably suited for use as a filtration medium, a candle being shown in Fig. 2, and other applications have already been found in air fluidised powder conveying and in aeration pads. Vyon is made in sheets up to 32 in × 32 in, from 0·03 in to 0·2 in thickness, which can be welded and drilled.

FOAM REINFORCED DINGHY

Bristol Aircraft has, for perhaps the first time, reinforced a glass-fibre structure with plastics

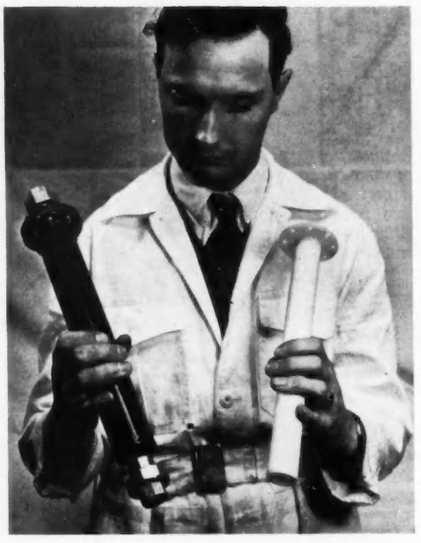


Fig. 2 Porous high density polyethylene is used in chemical engineering.

foam. The structure is a hull; the hull belongs to the Alpha 12 ft racing dinghy and the foam is a rigid polyurethane which is foamed *in situ*. Two large one-piece glass fibre reinforced mouldings make up the main hull which, it is claimed, is made strong and rigid by the foam; further, even if the Alpha were cut in two, both parts would float safely, because the foam acts as a buoyancy medium.

INERT PIPELINES

Ptfe is featured in Fuoroflex piping made by BTR Industries, Vincent Square, London, SW1. Fig. 3 shows some of the range of supported and unsupported piping including stainless and mild steel units lined with ptfe. Typical examples of the uses of Fluoroflex are in high pressure pipelines in the de Havilland Comet 4B, and circuits conducting highly corrosive fluids in the chemical and allied fields.

NYLON SCREWS

Nylon screws are inherently self-locking, and it is sufficient to screw them down by hand and then to apply one half turn with a screwdriver. The firm responsible for the development is GKN of Birmingham 18, who use ICI A100 nylon for the moulding process. The strength is

Fig. 3 Pipelines in ptfe have outstanding chemical resistance.

low—3,000 lb per sq. in in a wet atmosphere—but the advantages are those of the non-metallic nylon, including insulation, chemical inertness and non-magnetism. Suggested uses are in switch assemblies and hospital equipment.

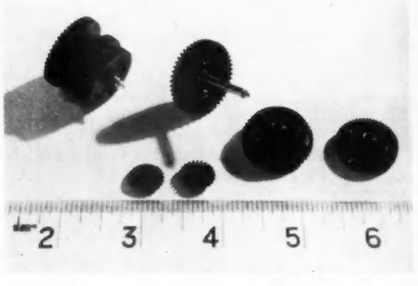
FRENCH NYLON 6

There are several thermoplastics which although produced from different chemical raw materials, have a similar chemical structure when in the polymeric form and are referred to generally as nylon plastics. A polycaprolactum type nylon is known as a type 6, and has more flexibility than the usual type 66 material. In the United States, Allied Chemical Corporation has announced commercial production of tyre yarn in type 6 with very good heat stability and resistance to flex fatigue. In this country this nylon is imported from the French firm of Rhodiaceta, by their associates—M and B Plastics Limited, Wigmore Street, London, W1. Technyl C, as the brand of nylon 6 is called, is especially suited to production of shock resistant mouldings.

FRENCH NYLON 11

From the continent again—Ralsin, nylon 11—made by Societe Organico, for whom Whiffen and Sons are sole agents in the United Kingdom, the address—Fison House, Wigmore Street, London, W1. This nylon 11 comes in five grades: one of them, G8, is graphited, and is particularly suited for gears and bearings, examples of which are shown in Figure 4. Like all nylons it absorbs water from the atmosphere but it does so to a very much smaller extent than any of the polyamides at present industrially available. The equilibrium is, in fact, about 0·5 per cent moisture which means good dimensional stability.

Fig. 4 Low moisture pickup of nylon 11 gives stable mouldings.



SPRAYING REINFORCED PLASTICS

Aust and Schüttler and Company of Düsseldorf manufacture fibre/resin spraying machines—for the mechanisation of hand lay-up without resort to preimpregnated materials. MAS machines are being employed in civil engineering for providing insulation and continuous coatings such as in pressure tunnels of hydroelectric plants, and for providing chemical resistant linings for the chemical industries. There are two types, the one of special design for civil engineering having a proportioning and admixing device for fillers. Deposition capacity rates of 65 kg per hr of cut glass fibres, and of 110 kg per hr of polyester resin appear to be standard.

COATING WITH PTFE

The Plasinter process, as operated by Darlaston Galvanised Holloware Limited of Wednesbury, is used to coat metals and plastics laminates with various plastics including pvc, ptfe, ptfce, nylon and polyethylene. The latest success is with ptfe—ICI Fluon—which has "excellent dielectric and insulation properties," a working temperature range from − 180° C to 250° C, and which is unaffected by ultraviolet light. All coatings are firmly adherent and allow machining or drilling without chipping or peeling.

NEW DEPARTURE IN CARGO CRANE DESIGN

Two years ago, Stothert and Pitt of Bath started work on a new project. This was a crane with clean lines and reduced weight, simple to operate and maintain, and well suited (with little modification) to the requirements of most users. The price had to be kept as low as possible but the crane had to follow British Standards Specifications.

The result of all this is their dockside crane (described here), which can lift 5 tons at 80 ft radius (or as an alternative, 6 tons at 70 ft radius).

Fig. 2 (above) Shows how the X-bracing is disposed between the four main members, each of which is designed to carry exactly the same load.

Fig. 3 (below) The clean lines and simplicity of construction of the crane are most noticeable.

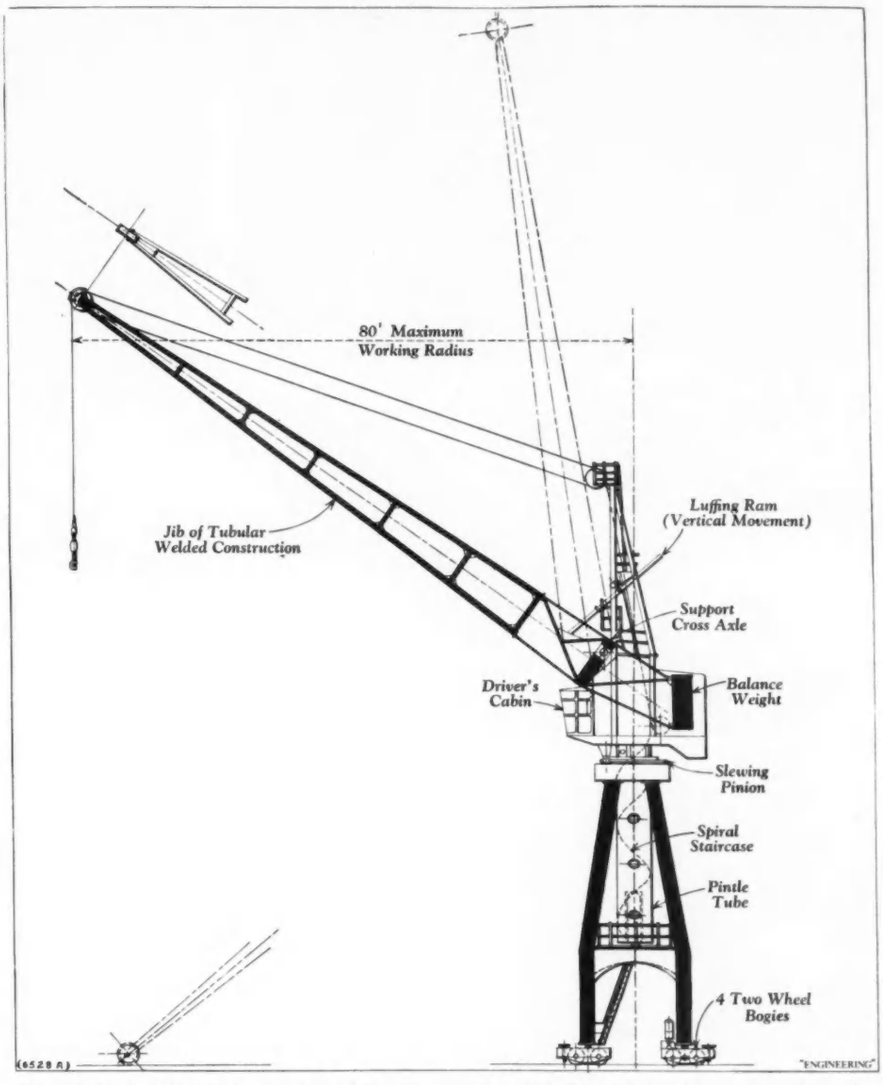


Fig. 1 (above) The jib is straight and has three sections bolted together, with a minimum number of members. There is no diagonal bracing; the welded ends of the members provide stiff joints.

THE clean lines and simplicity of construction of this crane are at once apparent.

The crane is of welded construction with a minimum number of members bolted together at site. Secondary and breaking-up members have been eliminated where possible by increasing the strength of the main members, arranging these in the most effective way and using modern construction methods. Members are generally tubular, to give maximum strength-to-weight and stiffness-to-weight ratios. This reduces the surface area subject to atmospheric corrosion and, of course, the area that requires painting. (This area is, in fact, about half its usual value.)

A long pintle tube (Fig. 1) attached to the underside of the superstructure is fitted, at the upper end, with three adjustable rollers which rotate inside a segmental roller path bolted to the truck top. The outside of the ring has spur teeth for engagement with the slewing pinion. The lower end of the pintle tube is supported by an oil immersed roller thrust and journal bearing.

The jib is straight and consists of three sections bolted together, each of tubular welded construction, with a minimum number of members. For example it will be seen from Fig. 1 that there is no diagonal N-bracing. The welded ends of the members provide stiff (fixed) joints to make this possible.

The four main jib members are designed to carry the same maximum load, and there is X-bracing between them, as will be seen from Fig. 2. The dead weight of the jib is balanced in all positions by the balance weights, which are triangular in plan form in order to get the maximum moment with the minimum weight and tail radius (see Fig. 5).

There is one pulley spindle at the head and the rope angles are such that there is no need for a back pulley near the apex of the jib. The end moment in the jib due to the loads from this pulley are therefore dispensed with.

Angular movement of the jib (luffing) is by a single, centrally placed hydraulic ram of original design which gives smooth acceleration and deceleration of the jib in all positions, whatever the operator may do. Overload or jerky motion is impossible.

A specially developed, simplified, Ward-Leonard set drives the hoist winch through double helical and spur gearing. It has an

Fig. 4 (left) There is an excellent view from up here in the driver's cabin.

Fig. 5 (right) The balance weights are triangular in plan form in order to get the maximum moment with the minimum weight and radius.

exciter, energised by the current in the armature loop circuit, which simultaneously controls the winch motor field and the generator field. This has many advantages.

The driver's cabin (Fig. 4) is of resin-bonded glass fibre and galvanised steel. "Rubber glazed" safety glass is used throughout and there is a window in the floor and another in the roof. An adjustable seat is provided for the driver to operate the crane with joystick controls.

The four two-wheeled bogies are fitted with swivelling (and rocking) gear to minimise cross-racking and enable the crane to negotiate curves. Two of the bogies are fitted with travel gear in which the motor drives through a fluid coupling and worm and spur gear to both wheels. Automatic solenoid-controlled brakes are fitted to the powered bogies and there is a hand-operated safety locking device on the otherbogies.

The machinery house is constructed of translucent resin-bonded glass fibre which, without windows, gives a soft uniform lighting within. A wall crane is provided inside the house, capable of lifting any of the machinery units. There are jack-knife doors at the back so that any of the units inside can be swung out.

PRACTICAL FUEL CELL GIVES ELECTRIC POWER

A team working in Cambridge (under the sponsorship of the National Research Development Corporation) has produced the Bacon Hydrox fuel cell which has an output of 5 kW at 24 volts.

For over 100 years scientists have been trying to produce a practical fuel cell. First thought of in 1839 by Sir William Grove, a fuel cell (which converts chemical energy direct into electrical power) did actually work in 1899 but lack of suitable materials and technology prevented its further development. A lot of work has been done, however, in many countries since the Second World War.

Ten years of original research were carried out at Cambridge University under the auspices of the Electrical Research Association and the Ministry of Power, before the National Research Development Corporation placed a development contract with Marshall of Cambridge in 1957. Mr. F. T. Bacon, M.A., A.M.I.Mech.E. (who has been intimately associated with the project for 20 years) is head of a team carrying out development work at Marshall's, where the hydrogen-oxygen (Hydrox) cell has now become a practical proposal. The Admiralty has also sponsored some of the work carried out by Bacon.

Other methods of producing electricity rely on heat engines such as steam turbines and petrol or diesel engines. All burn fuel and, in turn, drive generators. These methods involve several steps before electrical power is produced and for this reason have a fairly restricted efficiency. The fuel cell, by producing electricity in one stage, can achieve efficiencies of about 80 per cent, which is much better than that by conventional methods.

The largest fuel cell previously made was one of six 5 in diameter cells in series. The one now produced consists of 40 cells each 10 in in diameter, together giving an output of 2½ kW at 32 volts (or 5 kW at 24 volts maximum load conditions). For this, a great many new technical problems have been solved, and automatic controls have been developed.

HOW IT WORKS

A fuel cell is an electrochemical battery in which the free energy of combustion of a fuel is converted directly into electrical energy. The hydrogen-oxygen cell operates by a simple reversal of the process of electrolysis of water.

Each cell unit consists of two electrodes, one for hydrogen and the other for oxygen, separated by an electrolyte. The electrodes are made of porous an sintered nickel, with a thin layer of a smaller pore size on the liquid side. The oxygen electrode is treated with lithium and pre-oxidised to prevent corrosion. The electrolyte is strong caustic potash, and working conditions are around 200° C and 400 lb per sq. in. The electrolyte soaks into the sintered metal but, on the application of the gas under pressure from the back of the plate, is expelled from the larger pores only since the gas cannot bubble through the smaller-pored surface because of the surface tension of the liquid. There is thus a very large surface (about 40 sq. m) of wetted sintered metal in contact with gas in each electrode.

Oxygen molecules on the positive electrode combine with water to form negatively charged hydroxyl ions each of which removes an electron from the oxygen electrode. The hydroxyl ions migrate through the electrolyte to the negative electrode where they combine with the hydrogen to form water, depositing an electron in the process. Thus the hydrogen electrode becomes negatively charged with respect to the oxygen electrode and a current flows in the external circuit. To remove the water formed, the hydrogen is circulated past the back of the hydrogen electrodes and the mixture of hydrogen and steam is cooled externally, so that the condensate can be released as required.

Much work has been done on the control system, since the pressure of the two gases must be very evenly balanced if damage is to be avoided. The present system is to keep the oxygen pressure constant and to control the hydrogen pressure against it by a very accurate differential pressure meter, actuating a power-operated inlet valve controlled by a servo-mechanism. Other problems of initial heating and subsequent cooling have also had to be solved.

The hydrogen-oxygen cell has completed the second stage of development and is now approaching the commercial proposition of a completely automatic and reliable battery, capable of producing power at a moment's notice in a practical installation. In this sense, it is an electrical accumulator. When the National Grid (or the nuclear power stations) are running at less than optimum load, the surplus could be used for electrolysis to feed a hydrogen-oxygen cell as a source of auxiliary power. It is unlikely, however, that the fuel cell battery will ever be competitive with existing types of accumulator in small sizes, because of the high cost of control gear in comparison with the overall cost of the plant. Power outputs of less than 100 watts are not likely to be economic.

Advantages of this kind of fuel cell are that it is able to take large overloads at reduced efficiency without damage, it is silent and free from vibration in operation, it has very few moving parts and the "exhaust" is only water. "Charging," moreover, would merely consist of refilling with the two gases, a very rapid process indeed.

With the advent of new methods of storing hydrogen and oxygen (either in liquid form or, in the former case, as a compressed gas at very low temperature) it is conceivable that vehicles could be propelled over really long distances with fuel cells.

APPLICATIONS

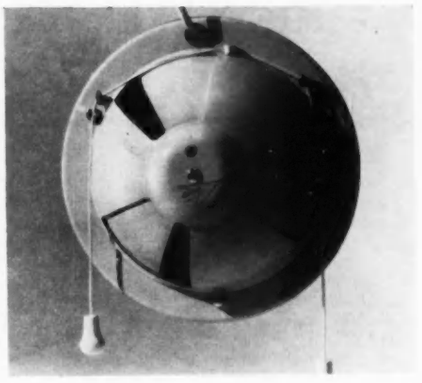
Applications of the fuel cell range literally from fork lift trucks to space vehicles. Rail traction, for instance, is an attractive proposal. An electric locomotive equipped with a fuel cell (fed from containers of oxygen and hydrogen) could operate over long distances. It would need no overhead wires or conductor rails. The cell would produce its own electricity for driving the electric traction motors. Heavy tractors are another possibility, as are public service vehicles. There could be trolley buses without overhead wires and with their own self-contained power stations.

Applications for aircraft are also being considered and there is a promising field for the use of fuel cells as auxiliary power sources for rockets and space vehicles where lightness and endurance are required.

The United States have shown considerable interest in British developments in fuel cells and The Universal Winding Company over there has already become a licensee of the National Research Development Corporation. The Patterson Moos Division of the Universal Winding Company (using information supplied by the NRDC) has already manufactured units of the Bacon type for delivery to the US Air Force.

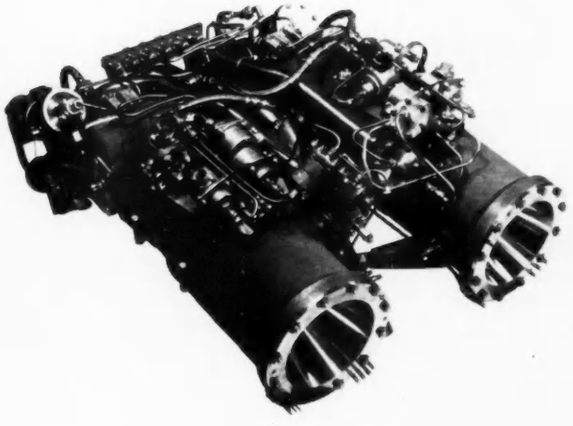
(*Above*) *The old (replica of 1912 Curtiss pusher biplane) and the new (first Boeing 707-420 Intercontinental jetliner for BOAC) on parade in Vancouver.*

(*Right*) *No, it is not an adjustable topee but a ventilator fan (with control cords of nylon) designed to fit into any window.*



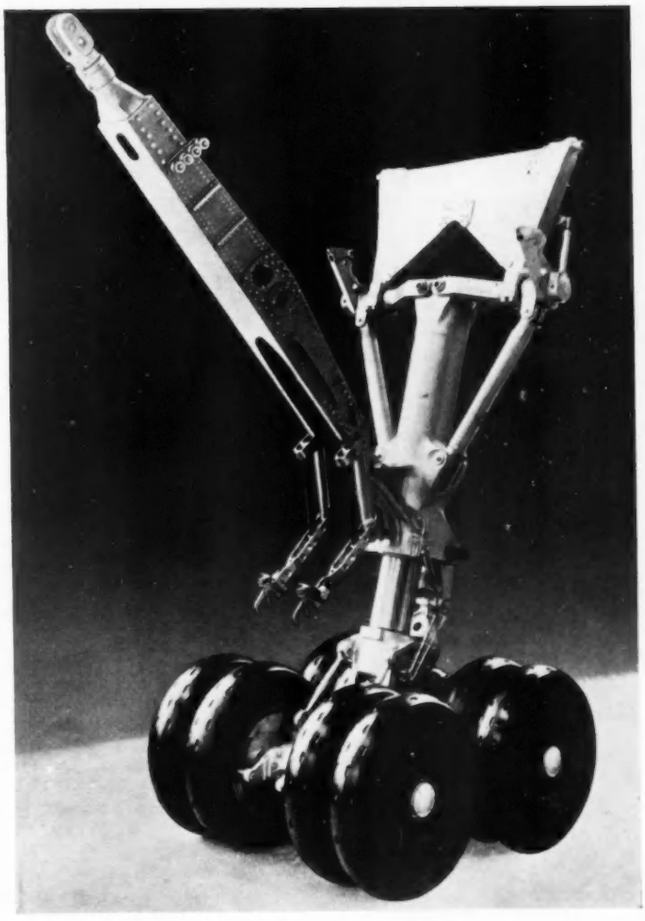
(*Below*) *24 ft lifeboat of glass fibre reinforced polyester resin. Hand propelled, the chain drive is totally enclosed in a casing.*

(*Below*) *Semi-articulated multi-wheel bogie undercarriage for the Handley Page Victor. Complete tricycle is only 3 per cent of the all-up weight.*



(*Above*) *Binocular-like Double Scorpion aircraft rocket engine uses high test peroxide as oxidant and standard aviation kerosine or gasoline as fuel.*

(*Left*) *Simplicity is the keynote of the face-lifting on this short scale switchboard ammeter. How easy the dial is to read.*



HIGH PRESSURE PUMP

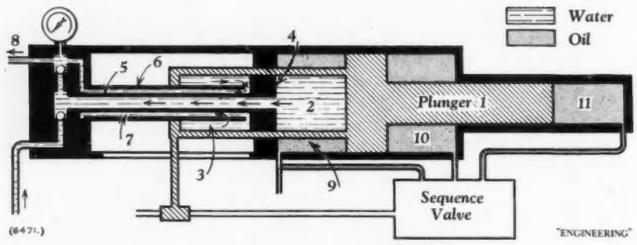


Fig. 1 How it works. For explanation see below.

Plunger (1), which reciprocates inside the stationary part of the pump (shown solid), acts as a piston in the oil (operating medium) and as a cylinder in the water section of the pump.

Water fills two independent chambers (2) and (3), chamber (3) being half the capacity of (2). The stationary water piston (4) surrounds the water inlet tube (5) leading into chamber (2). Tube (5) has an outer case (6), the annular space (7) thus formed being part of the chamber (3).

Movement (by oil pressure) of the plunger to the right fills chamber (2) with water and empties chamber (3) via passage (8).

Movement of the plunger to the left empties (2) of water: half its contents go to the water delivery (8) and half to fill chamber (3).

Delivery from the pump thus takes place through (8) on each stroke, but suction only on alternate strokes.

(9) is a constant pressure oil return, while (10) and (11) can act together or independently.

AN unconventional design of high pressure pump—the Hydraflo—has been developed by Tangyes Limited, Birmingham. It has no crankshaft, connecting rod or reduction gear; it is smaller and lighter than a conventional pump; and it requires no servicing.

The principle of the Hydraflo is simplicity itself. Oil hydraulic power is used to reciprocate the plunger, instead of using a conventional system of gears, crankshafts and connecting rods. (For details see Fig. 1.)

In the new design, a large diameter piston is used (working at slow speed) and requiring fewer cycles for the same pumped volume. Wear on seals and valves is thus less. The piston speed of the pump is constant over a complete cycle, so there is an almost straight-line, continuous output, as will be seen from the comparative discharge curves of Fig. 2.

The original Hydraflo pump (designed for coal infusion duties) is capable of outputs of 1,000 gallons per hr at 1,500 lb per sq. in and this can be changed by a push button to 500 gallons per hr at 3,000 lb per sq. in. Although this design has been used principally for colliery work, the potential field is wide.

Recent development has increased the range to cover pressures up to 9,000 lb per sq. in, outputs up to 4,000 gallons per hr and powers up to 90 b.h.p. The output can now be infinitely variable over a wide range.

Crank-driven, reciprocating, double-acting, single-cylinder pump, with a connecting rod; crank ratio of 5 to 1.

Hydraflo pump, double acting, single cylinder.

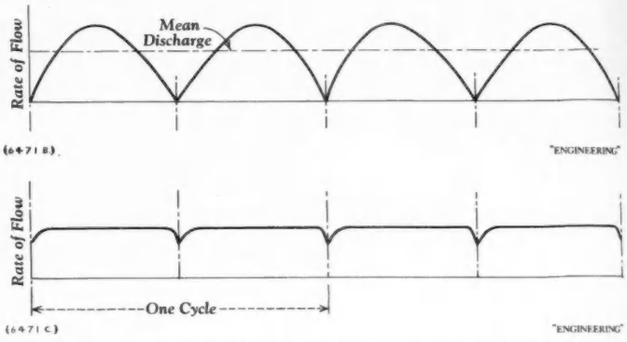


Fig. 2 Comparative curves for identical output under similar line conditions.

USEFUL CHARTS FOR TAPERED BEAMS

THE Hardy Cross moment distribution method of solving continuous beams is well served by a report published by the Department of Civil Engineering, Stanford University, California (and distributed by the American Institute of Steel Construction, Inc.). Called *Moment Distribution Factors for Beams of Tapered I-Section*, by James M. Gere, it contains some excellent charts for solving straight-tapered beams (of I and box section) that will be real time-savers in the design office.

In the moment distribution method each span (it will be recalled) is first treated as an independent fixed beam and the resulting end moments determined. Any resulting out-of-balance at the supports is overcome by applying an equal and opposite releasing moment, which is distributed between adjacent spans with due regard to their stiffness.

To use the AISC charts for a structure with tapered members (the illustration shows a typical example of a 2-span continuous beam) all that has to be done is find the following items:

(1) *Shape Factor (n)*

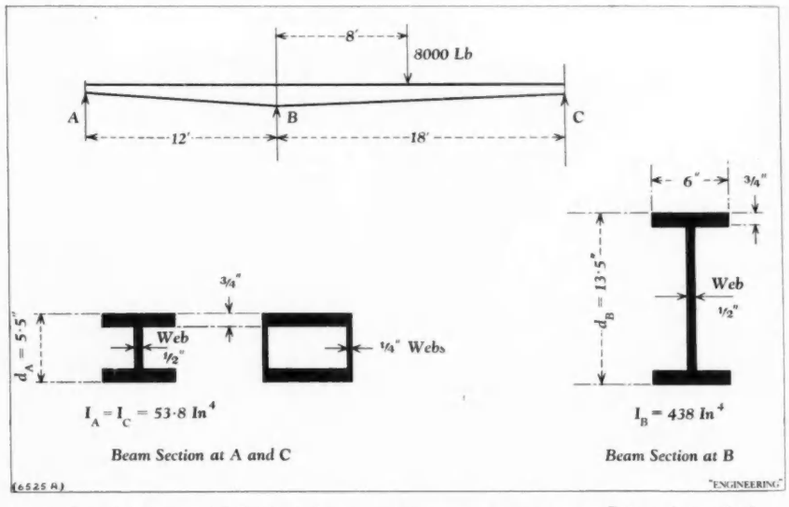
This depends entirely on the cross-sectional dimensions of the beam and is given in chart form in terms of the ratios d_B/d_A and I_B/I_A.

Here d_A, d_B = total depths of beam at A and B. I_A, I_B = moments of inertia of cross-section at A and B.

(2) *Carry-Over Factor*

For a beam A B, a moment M_A applied at A will induce a moment M_B at B. For a non-tapered beam, $M_B = \frac{1}{2} M_A$ and the carry-over factor from A to B is thus $\frac{1}{2}$.

For the tapered beam, the carry-over factor is read from the appropriate chart in terms of n and d_B/d_A. Its value is greater (or less) than $\frac{1}{2}$, depending on the direction of taper.



Typical straight-tapered I (or box) beam, continuous over two spans, to show the method.

(3) *Stiffness Ratio*

The stiffness at B of a beam A B is the moment that must be applied at B to cause unit change of slope there. For a fixed-fixed beam of constant depth, $M_B = \frac{4EI}{L}$

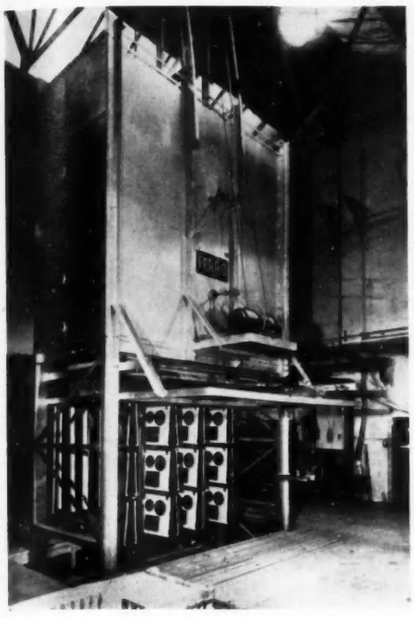
For the tapered beam, the stiffness is given in chart form in terms of d_B/d_A and the ratio EI_A/L, where L is the span.

(4) *Fixed-End Moments*

For non-tapered beams, these would usually be obtained from a standard textbook for a particular loading.

For the tapered beam, the values are charted for a number of loading conditions, in terms of n and d_B/d_A.

Once items (1) to (4) have been found, the moment distribution calculations follow a familiar pattern as for a non-tapered beam.



MORE EFFICIENT ENAMEL FIRING

A remarkable improvement in thermal efficiency is one of the features claimed for the new vertical or "tower" batch enamel firing furnace introduced by Ferro Enamels Limited, Wombourn, Wolverhampton.

The furnace casing is mounted vertically, with the door at the bottom, the opening being about 9 ft above floor level. With the door in this position, the heat loss when a load is charged or removed is very much less than is the case with a conventional "box" type furnace with the door at one end.

Heating is electric, there being two automatically controlled zones within the insulated casing, the elements being displaced over the sidewalls only, where they are easily accessible for inspection and maintenance. The charge is carried on hangers suspended from a heat resisting alloy suspension bar, which is, in turn, hung on two suspension rods extending through the furnace roof and terminating in a yoke. Two roller chains connect this yoke to a push button-controlled electric hoist mounted on the furnace supporting framework. The load hangers can thus be raised and lowered as required for charging and withdrawing the work to be fired. At its lower limit of travel the suspension bar runs out on to an overhung transfer frame. Two suspension bars are kept in normal use, one in the furnace and the other on the transfer frame being unloaded and loaded again with fresh components ready to go into the furnace. A simple manual operating gear opens and closes the door; this is interlocked with the load hoist to prevent wrong-sequence operation.

As a result of its shape and method of charging, the furnace is ideally suited to the firing of long narrow components such as trough reflectors for fluorescent lighting (for which it was, in fact, originally designed), but it can equally well be used, with slightly different load hooks, for smaller and differently shaped articles. It can also, of course, deal with mixed loads, varying shapes and sizes of component being accommodated simultaneously without difficulty.

The design, which is also economical of floor space, lends itself to virtually any size likely to be required. As illustrated herewith, the furnace has an installed load of 200 kW, and an inside clearance 10 ft high, 8 ft long and 2 ft wide. An average production loading is 80 kWh, with an output of eight to ten loads per hour, depending on the weight and type of articles being fired.

HOW TO HANDLE BOXES, DRUMS AND SACKS

Included in a new series of sound film strips produced by the Industrial Welfare Society in cooperation with the Central Council of Physical Recreation, are three on the handling of boxes, drums and sacks respectively. They will serve to augment the society's work in this sphere, which already includes demonstrations and the running of residential courses in manual lifting and handling. The importance of this work is brought home by the annual report of the Chief Inspector of Factories, which announced that in 1958 there were 43,623 accidents involved in "handling goods or articles in manufacturing or carrying processes." This category of accident represented the greatest under a single heading.

Though obviously directed at industry, these film strips should also find a home in the teaching curricula of our technical colleges, where young men can be taught how to work safely before learning by their own mistakes. These film strips, and others on human relations in industry, are available to both members and non-members of the society from Robert Hyde House, 48 Bryanston Square, London, W1.

FOUNDRY FOR INGOT MOULDS

In the bicentenary year of the Dowlais Ironworks in South Wales, a new foundry for casting ingot moulds has been opened.

Just 200 years ago a solitary little blast furnace was built at Dowlais, in South Wales, and a year later John Guest took over the management. That was the beginning of Dowlais Ironworks, which became world famous. Its history has been written many times. Pioneer producer of iron rails for the world's railways—maker of the first Bessemer steel rails—at one time the largest ironworks in the world—these are some highlights of Dowlais history. Exhaustion of local raw materials led to the erection of new works at Cardiff in 1888 and to the eventual closure of Dowlais Ironworks in 1930. The foundry, however, known as Ivor Works, Dowlais, carried on, making general castings for the steel and engineering industries and, in particular, steelworks ingot moulds.

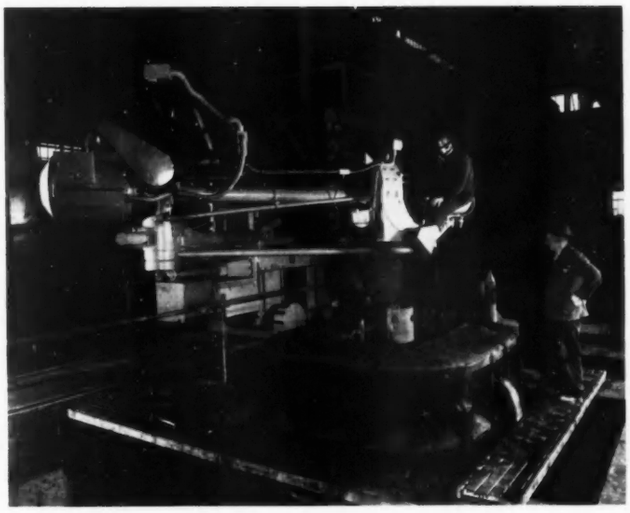
Today, the works are owned by the Guest Keen Iron and Steel Company Limited, who have carried out an extensive reconstruction scheme. At a cost of over £2 million the new ingot mould foundry has been built.

Ivor Works consist of a jobbing foundry producing general castings at a rate of 100 tons per week, the maximum individual weight being 20 tons; a brass foundry making 3 tons per week of general castings up to 2 tons individual weight; a structural shop for general engineering work; a pattern shop; a machine shop; a clay mill producing 500 tons of blast furnace clay per week; and the new ingot mould foundry.

Designed and equipped solely to produce ingot moulds from 4 to 25 tons, and mould bottoms from 1 to 8 tons in weight, the foundry occupies an area of 164,000 sq. ft and can make at least 1,000 tons of castings per week on normal single shift working. With a double shift the output could be raised to 1,800 tons per week or more. High production rates have been achieved by the maximum possible mechanisation.

Moulding is by a travelling Beardsley and Piper (Chicago, USA) "Speed-slinger," capable of ramming 50 tons of sand an hour (see illustration). The patterns for the bottom plates are stripped on a large roll-over machine. Generous provision of overhead cranes, roller tracks and transfer bogies makes mould movement easy.

Three mechanically-charged cupolas, each of 30 tons an hour melting capacity, provide the iron, which is cast from bottom-pour ladles.



Moulding with a travelling "Speed-slinger" which can ram 50 tons of sand an hour

Castings are cooled on a grid, with sand conveyors below it to return used sand to the preparation plant.

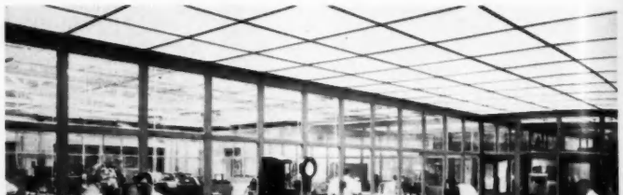
When they are broken out of the mould the castings are cleaned by Hydroblasting. Fettling with pneumatic tools follows, and machines are installed for end machining moulds and for drilling dowel holes.

HIGH PRECISION BEARINGS

Developed by M. Louis Gamet in France, the Gamet taper roller bearing was designed specifically for machine tool spindles. It has proved highly successful, and is used extensively both in the land of its origin and in other countries, including Great Britain. Manufacturing rights for the bearing were acquired in 1954 by the George Cohen 600 Group and after a period of manufacture in France, during which British technicians were trained, production facilities were set up in Colchester. These proved adequate for a time, but it became obvious that increased facilities would be needed, and an entirely new factory was planned. This has now been completed and is in full scale production.

Operated by Gamet Products Limited, at The Hythe, Colchester, the new factory is designed for maximum flexibility in plant layout, and, above all, for quantity production to a very high degree of accuracy. Gamet bearings, which are produced in a standard range of English and metric sizes, from 35 mm (1⅜ in) to 210 mm (8 in) shaft diameter, have guaranteed tolerances of 0·001 mm (0·000039 in) on radial run-out, and 0·005 mm (0·0002 in) on bore and outside diameters. The bearings incorporate hollow rollers held in a light alloy cage of special design, and as a result the lubricant flows smoothly through the bearings without churning or temperature rise. Consequently, the bearings can run over a wide range of speeds without loss of accuracy or rigidity.

To produce consistently to such limits both the factory and the equipment have had to be designed specially. Minimum temperature variation is an obvious requirement in the production building, and the main shop, 250 ft long and 104 ft 6 in wide, is built with cavity walls lined with lignasite brick. The roof has an inner and outer skin of asbestos with a layer of fibreglass between. There are no windows, the natural lighting being by means of double-glazed roof lights. For cleanliness ferro-concrete tiles are used on the floor, and the walls are tiled in pale grey up to a height of 10 ft. All the remaining parts of the walls and the steelwork are painted white, and the flush lining of the asbestos roof is painted a pale blue-green. All the doors are flush and are lined with pale grey Formica. Heating is by a Provenair fully automatic oil-fired plant, with air filtration and a high level duct distribution system.



Gamet bearings are made to very close dimensional limits. A fully air-conditioned room is provided for the inspection of components and assembly.

MACHINING

Machine tools of orthodox types are used in the production of bearing components, but the grinding equipment includes machines which were specially developed for the high-precision work involved. Internal grinding of inner ring bores and outer ring tracks is finished on French made Voumard machines developed specially for the work, and external grinding is done on French Gendron Freres machines and on British Jones and Shipman machines, automatic control of diameter being provided by Taylor-Hobson equipment sequenced into the work cycle. Heat treatment of components is by means of five batch furnaces by the Electric Resistance Furnace Company Limited.

INSPECTION AND ASSEMBLY

A separate room, constructed of Sankey-Sheldon steel partitions, is provided in the centre of the factory, where it is away from external atmospheric influences, for inspection and assembly of bearings. Glass wool insulation and double doors provide a seal at the entrance to the room, and air conditioning plant by Climatic Controls Limited maintains the air temperature at 68° F ± 2° F and relative humidity between 45° and 30°. There are ten air changes per hour. A cork floor minimises vibration.

To ensure absolute cleanliness of components before inspection and assembly, Kerry ultrasonic cleaning plant is used. Every component is checked for hardness, a Reicherter automatic Rockwell hardness testing machine being among the equipment provided. Other inspection equipment includes a Taylor-Hobson "Talyrond" roundness measuring instrument, and an SIP universal measuring machine.

Operation and Maintenance

INSURANCE — FROM BOILERS TO NUCLEAR ENERGY

A century ago public opinion was alarmed at the number of boiler explosions which took place. Nobody knew the full extent of the toll of human life and damage to property, for there were no statistics available; but that boiler explosions did take place with alarming frequency, and often with disastrous results, was a well known fact. There was general agreement that something ought to be done, and it was against this background that boiler insurance—to develop eventually into the familiar industrial insurance of today—came into being. But if the seriousness of the situation was acknowledged, there were differences of opinion about possible remedies. Insurance of boilers was attacked in some quarters on the grounds that it would give boiler users a false sense of security, and be the cause of even greater carelessness in boiler operation.

How that objection was overcome, and how boiler insurance developed until the insurance company's inspector became the well known and respected figure he is today, is told by W. H. Chaloner in *Vulcan, the History of One Hundred Years of Engineering and Insurance*.*

An attempt had been made in 1854 to provide some form of guidance for boilers users, when, at the instigation of Sir William Fairburn, the Manchester Steam Users Association was founded. The MSUA, however, did not at first offer any form of insurance, and it was not until 1859, when the Vulcan business (then known as the Steam Boiler Assurance Company) was formed, that it became possible to insure boilers against explosion.

From the first the company made it a condition of insurance that boilers should be examined at stated intervals by their own engineering inspectors, and the early reports of the inspectors reveal the extraordinarily casual manner in which boilers were all too often used. Wedging of safety valves, for example, was often encountered, and attempts were made to excuse it on the grounds that the valve was not steam tight. Inspectors who discovered dangerous situations were not always welcomed; one, who put his chisel straight through a boiler shell, was the target of abuse from the owner, who objected to his having ". . . come there to make holes in the boiler"!

In the early days of the business there were no legal obligations on the user of a land boiler, except that in the event of a fatal accident a coroner's jury might (but rarely did) bring in a verdict of manslaughter against the owner or operator. A start on boiler legislation had been made in 1851, when a measure of control was imposed on marine boiler users, but nothing was done to regulate land boiler operation until 1882, when the Boiler Explosions Act was passed. This provided for heavy penalties on boiler users proved to have been negligent.

It was not without a struggle that boiler insurance became firmly established, but the business expanded steadily, and, at the same time, new lines were developed. Insurance against claims under the Employers' Liability Act, 1880, was provided for the contractors building the Forth Bridge (1884), Tay Bridge (1885), Tower Bridge and Manchester Ship Canal (both 1890), and the insurance of the Folkestone Lift Company's machinery in 1886 was the forerunner of a comprehensive scheme for lift and hoist insurance. In 1898 electric motors and dynamos were added to the list and this department grew steadily as the older steam engine section contracted. Oil engines, too, came under insurance cover, and by the late 1940's another new risk was undertaken—that of radioactive isotopes.

Steam boilers, the original object of the Vulcan Company's business, have increased in size and, naturally, decreased in number, but they are still an important item, together with the many other types of machinery which engineering insurance now covers.

* Published privately by the Vulcan Boiler and General Insurance Company Limited, 67 King Street, Manchester.

Operation and Maintenance

CLEAN AIR FROM STEELWORKS

Two electrostatic precipitator plants, ordered from the Koppers Company, Pittsburgh, are of special interest. Both plants are for cleaning gases from open hearth furnaces; one will go to the Pittsburgh works of the Jones and Laughlin Steel Corporation, and the other will be installed at the plant of Cornigliano SpA, in the suburbs of Genoa, Italy. The Jones and Laughlin plant is of interest because it will be installed in a city which has become very well known both in America and abroad for its campaign against air pollution, and the Cornigliano plant is significant as the first of its type in Europe.

Both plants are to be part of a complete contract designed by Koppers and including waste heat boilers, fans, stacks and ducting, the precipitators functioning as a central dust-collection system for all the open hearth furnaces. At Jones and Laughlin the specified efficiency of particle removal under normal operating conditions will be 98 per cent, and at Cornigliano the figure will be 97·8 per cent. In both cases "normal operating conditions" has been specified as including oxygen lancing on the furnaces, a process which, as is well known, reduces the refining time for each furnace charge, so improving operating efficiency, but, at the same time, increases the dust loading of the furnace gases.

For Jones and Laughlin there will be seven units each 34 ft high, 25 ft wide and 27 ft long, each unit being divided into three separately energised precipitation zones or fields. They will be coupled to an existing unit, and their combined gas handling capacity will be 1,178,000 cu. ft per min at the normal operating temperature of 550° F; this capacity is slightly in excess of the maximum gas output of the eleven open hearth furnaces. For Cornigliano the plant, similar in design to that for Jones and Laughlin, will have capacity of 584,000 cu. ft per min, which is less than the combined gas volume from the six open hearth furnaces, but as the melting plant is so operated that the furnace heat cycles are staggered, the apparent deficiency in precipitator capacity is theoretical rather than actual. Provision will be made in the Cornigliano precipitator shells for the addition of a fourth field at a later date if required.

Both installations will employ the "Koronamax" discharge electrode, developed by the technical associates of the Koppers Company in Great Britain, W. C. Holmes and Company Limited, Turnbridge, Huddersfield, for use by their Gas Cleaning Division, and first used for open hearth furnaces at the Fairless Works, near Trenton, USA, of the United States Steel Corporation. The Koronamax electrode is a two-strand, braided wire with barb-like points scientifically spaced along its entire length. The tendency of the current to collect at the barb points results in control of the corona discharge throughout the entire precipitation zone to a much greater degree than with the conventional single wire, and enables the plant to be operated at much higher efficiency.

Vibrators, which periodically rap the discharge wire assembly and collecting plates to dislodge accumulated dust, will be equipped at both plants with Koppers "K-30" pistons, in which the wearing surfaces are faced with a combination of synthetic materials requiring no lubrication. Another innovation will be the use of drag-scraper bottoms instead of conventional hoppers for the collected dust. These scrapers are in successful use on precipitators in other industries, but the Jones and Laughlin installation will be their first application in the United States for use with open hearth furnace gas cleaning plant.

SAVING PAINT

Each time a skin forms on the surface of paint in tanks during production, as much as half a gallon of paint can be wasted. In addition, removal of the skin and the dust which settles on it is a troublesome operation, and it is practically impossible to remove all traces.

Alexander, Fergusson and Company Limited, Glasgow, have found the answer to this problem in the form of polyethylene discs, supplied by E. S. and A. Robinson Limited, Bristol. The discs are made to fit the interior of the tank closely, and can be placed in position in a matter of seconds. Being flexible, they can be squeezed out easily on removal, and they are so cheap that they can be thrown away after having been used once.

FOUNDRY AUXILIARIES

Handling in foundries (which may be combined with other operations, for example, both coring and casting, can be done while a mould is being conveyed); sand preparation; and core drying; all had their place at the recent Foundry Exhibition.

Paterson Hughes Engineering Company Limited, Bedford Street, London, WC2, for instance, exhibited samples from their range of conveying and lifting machinery, and provided information on their foundry equipment service, which undertakes the complete provision of foundry machinery, covering all aspects of the subject, from receipt of raw materials to despatch of finished products.

Modern Furnaces and Stores Limited, Booth Street, Birmingham, 21, showed a rotary sand drier and three different forms of portable mould drier, heated by oil, gas and electricity respectively. These driers are designed to supersede the old open fires which current regulations forbid.

Marketing

Floating Showroom

Proposals have been put forward for the conversion of a surplus British light aircraft carrier into an exhibition ship for the display of British products of all kinds at the world's ports, in the form of a floating exhibition. The organisers envisage that the project shall continue for approximately three years from the Ocean's departure on her first voyage, and propose catering for firms who would present permanent showcase exhibits as well as for those who prefer to book space "by the voyage."

During the first twelve months of operation, the provisional programme is that the Ocean shall visit ports on the east coast of South America, the east coast of Canada, western Mediterranean ports and towns on the Baltic Sea. In general, with a quick turn-round between voyages, it is hoped that the vessel would make a minimum of four voyages a year, except during the second or third year, when voyages to Australasia and the Far East are planned.

A company has been formed, and it is stated that, to date, about 180 firms have either unequivocally promised their support or have at any rate indicated their favourable interest. The promoters will welcome further support and requests for details. These should be directed to Oceanwise Exhibits Limited, 22 Half Moon Street, London, W1.

New Light in the East

What is described as "man's newest light source" was on show at the Third International Trade Fair last month. The United States Government's exhibit included electroluminescent cells developed by the Westinghouse Electric Corporation. These lamps have no filaments, are flat, glare free and will burn night and day for a year for less than one penny. They consist of a phosphor coated on a glass panel which has been treated to conduct electricity. When power is applied the panel lights.

Mr. F. M. Sloan, vice-president of Westinghouse, said that this lamp was an entirely new product which had been on the market in the United States, for a few weeks only, under the name of "Rayescent Safety Light." It was intended for use in hallways, bathrooms, stairways, sick rooms, nurseries, bedrooms, and hospitals; in fact, in any location where low-level brightness was desired, so that a person could quickly orient himself to his surroundings, yet not be annoyed by light glare.

Cooperative Exports

The considerable progress which has been made in the promotion of cooperative exports in Norway during the past eight years is reviewed in the Summer issue of *Norway Exports*. Two national organisations, Noreno and Norconsultants, were set up in 1950 to enable Norwegian manufacturing concerns to pool their resources "for competing effectively in the Norwegian market."

Noreno was formed by a group of leading industrial, banking and shipping companies "with the purpose of securing orders abroad for Norwegian engineering firms and industries." The article, entitled "Engineering and Contracting Services for Export," reviews progress. The managing director of Noreno explains his organisation as "a clearing house for information and as a contact agency for individual firms or joint ventures which often have to be formed for special operations. He emphasises that it is the firms which individually or in groups bid for contracts and carry out the work.

Norconsultants represent a pooling of the resources of nine leading consulting firms in Norway in civil, mechanical and electrical engineering, and architecture. They employ some 200 fully qualified engineers and execute

work to the value of Kr 1,000 million (£50 million) a year. They have so far operated mainly in Ethiopa (with a branch office in Addis Ababa) and the Middle East.

Marriage of Class

The appointment of distributors in the United States by a British firm makes welcome news. Marconi's Wireless Telegraph Company Limited have selected Ampex Corporation (professional products division) of Redwood City, California, to act as sole distributors of their television cameras. Under the terms of the agreement Ampex will also be authorised distributors in the United States for the range of television camera tubes made by the English Electric Valve Company Limited, whose 4½ in image orthicon tube is used in the Marconi Mark IV camera.

In their announcement of the agreement the two firms referred to themselves as respectively " the leading United States manufacturer of magnetic tape recording equipment " and " Europe's largest manufacturer of professional TV and sound broadcasting equipment." Ampex will sell the United States television industry a package which will include their television recording and reproducing equipment and Marconi's camera which, they say, is the highest quality television camera available.

Czech Machines

Machinery will be the highlight of the Brno fair next month, and much of it will be of Czech manufacture. An article in the current issue of *FT* (Czechoslovak Foreign Trade) discusses the development of the country's foreign trade in machinery. In the ten years 1948-58, the engineering industry outstepped all others in Czechoslovakia and its output last year was 3½ times greater than the prewar level. A considerable effort is being made in the country's second five year plan to raise the engineering industry's share of the country's total industrial production to 35 per cent. During the past few years engineering products have accounted for some 40 per cent of the country's total exports. Last year they were 20 per cent higher than in 1957 and, the article states, the rate of increase is expected to be well maintained.

Another article in the same issue entitled " Czechoslovak Achievements in the Construction of Complete Plants " reviews the progress made in this direction since the war. This type of export currently accounts for nearly half the country's total exports of engineering products. Most of the plants were supplied to countries in the Soviet Bloc, particularly Poland, Hungary, and China. Packaged electric power stations, chemical factories, oil refineries, food canneries, wood working plant and shoe factories are some of the examples quoted in the article. It is a method of export which has been highly developed by German engineering manufacturers and which is currently becoming popular everywhere.

Jaguar in Mexico

Following the arrangements made last year by Jaguar Cars Limited, for the assembly of their cars by their Mexican distributors, Jaguar Automotriz de Mexico, the Coventry factory has now received an initial order for 500 cars representing a turnover of $1½ million.

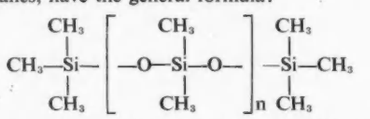
At Home

THESE SILICONES

Less than 20 years ago the family of chemicals known as the silicones was little more than a laboratory curiosity. Now they are a household word. In the period since the war they have invaded industry and the home alike to become part of daily life.

Silicones do not appear in nature: they are entirely man-made. Structurally they somewhat resemble the organic hydrocarbons with the carbon atoms in the chain replaced by siloxane groups.

The simplest silicone fluids, the polydimethylsiloxanes, have the general formula:



where n can vary from zero to over 2,000 and the corresponding viscosity from 0·65 to over 1,000,000 centistokes at 25° C. The resins are cross linked molecules of varying complexity and the rubbers are formed from fluids of viscosities from 10 to 12 million centistokes, cross linked by polymerisation and compounded with an inorganic filler.

The property above all others that made the silicones popular is their stability; the rubbers can be used at temperatures from − 80° to + 300° C; fluids remain fluid over the same range and the greases remain as greases. Nor does oxidation occur except extremely slowly. Other properties that make them valuable are their high electrical strength and their ability to repel water. It is not surprising therefore that they are used widely.

In the home silicones are used for all their characteristics; the fluids can be sprayed or painted on to walls or masonry to form a water repellent surface which nevertheless can " breathe " as the pores are not blocked. (The surface is therefore not " waterproof.") They can be used as coating on fabrics for the same purpose, or for cleaning eyeglasses. When applied to glass the siloxane group is strongly adsorbed leaving a surface of the hydrocarbon methyl group which has little affinity for water or for materials such as dust which are readily wet by water; such a surface is very easily cleaned. This non-stick property is also used for a very different application: to prevent batters and cake mixtures sticking to paper cups. The paper is given a very thin coating of fluid during manufacture and thereafter can be used quite normally being unaffected by the oven heat. Its use ensures that no part of the cake is left behind in the case, which is always a source of annoyance to the housewife. For similar reasons such paper can be used for wrapping sweets. Loaves come away easily and cleanly from tins that have been given a permanent coating of a silicone lacquer. In industry the non-stick properties of the silicones are used for somewhat similar purposes as a parting fluid in mould work and facings for rolls in the formation of plastics.

Silicone polishes are now on the market. Those for cars usually contain about 3 per cent of silicone and about 3 per cent of wax in some solvent, or in a water emulsion. A high polish can be obtained very quickly with this mixture and it is believed that the silicone acts as a spreading agent for the wax. The finish is substantially that which would be obtained by the wax alone but the silicone confers non-wetting, non-spotting and easily cleaned properties to the surface. About 5 per cent of silicone added to a conventional furniture polish gives a very smooth high gloss finish and has a tendency to obscure hairline cracks. The water repellancy reduces spotting. However, the very smooth surface obtained makes a silicone polish unsuitable for floors.

Another application of the water repellent properties is to leather. Here the fact that the pores are not blocked is of great importance for the leather is left free to breathe. Suede shoes so treated do not " wet "; water remains on them as discrete drops that run off as soon as the shoe is moved. Similarly, leather jerkins can be treated giving a thousandfold increase in repellency in army leathers. Mud splashes can be wiped off and do not penetrate the surface. Book leathers will remain cleaner longer as well.

Apparently quite different is the use of the fluids in cosmetics and ointments. Advantages here are the stability, the fact that they lack odour, colour and taste, their non-toxicity and their water repellency. Silicone-containing barrier creams protect the skin from detergent solutions, electroplating solutions, acids and alkalis; they have also been found effective for preventing plaster of Paris adhering to the skin—a very welcome function as many sufferers from broken limbs will know. In ointments their use depends almost entirely on their water repellency; they have no known therapeutic value of themselves. Chapped hands and cracked lips can gain from this, as the ointment will remain in place. The fact that they do not go rancid makes them useful in hair lotions.

Silicone rubbers, silicone paints and silicone resins are met with in many of the machines that are now so common in the home. The rubbers are used as seals in steam irons and in refrigerators; the paints are met with on vacuum cleaners, oil burners and electric fires, and the resins as insulation on small motors (for example, washing machines) enabling the size to be reduced as the working temperature can be raised. Silicone rubber is used also for teats for baby's bottle as it can be sterilised without deterioration; the same property allows it to be used for tubing for blood transfusion and the like. Translucent grades have been especially produced for the medical, pharmaceutical, and food industries.

How are silicones made? There are two main processes for the first stage, forming chlorosilanes. The first uses silicon and methyl chloride, and in the second silicon and chlorine form silicon tetrachloride and then react with organic chlorides.

The chlorosilanes are separated by fractional distillation, which requires very accurate control as the boiling points are very close together. Moreover, the chlorosilanes themselves present a handling problem as they are highly toxic, very inflammable and extremely corrosive. After separation the chlorosilanes are hydrolysed and condensed and then blended to give the range of silicone products, each one tailored to suit its particular purpose.

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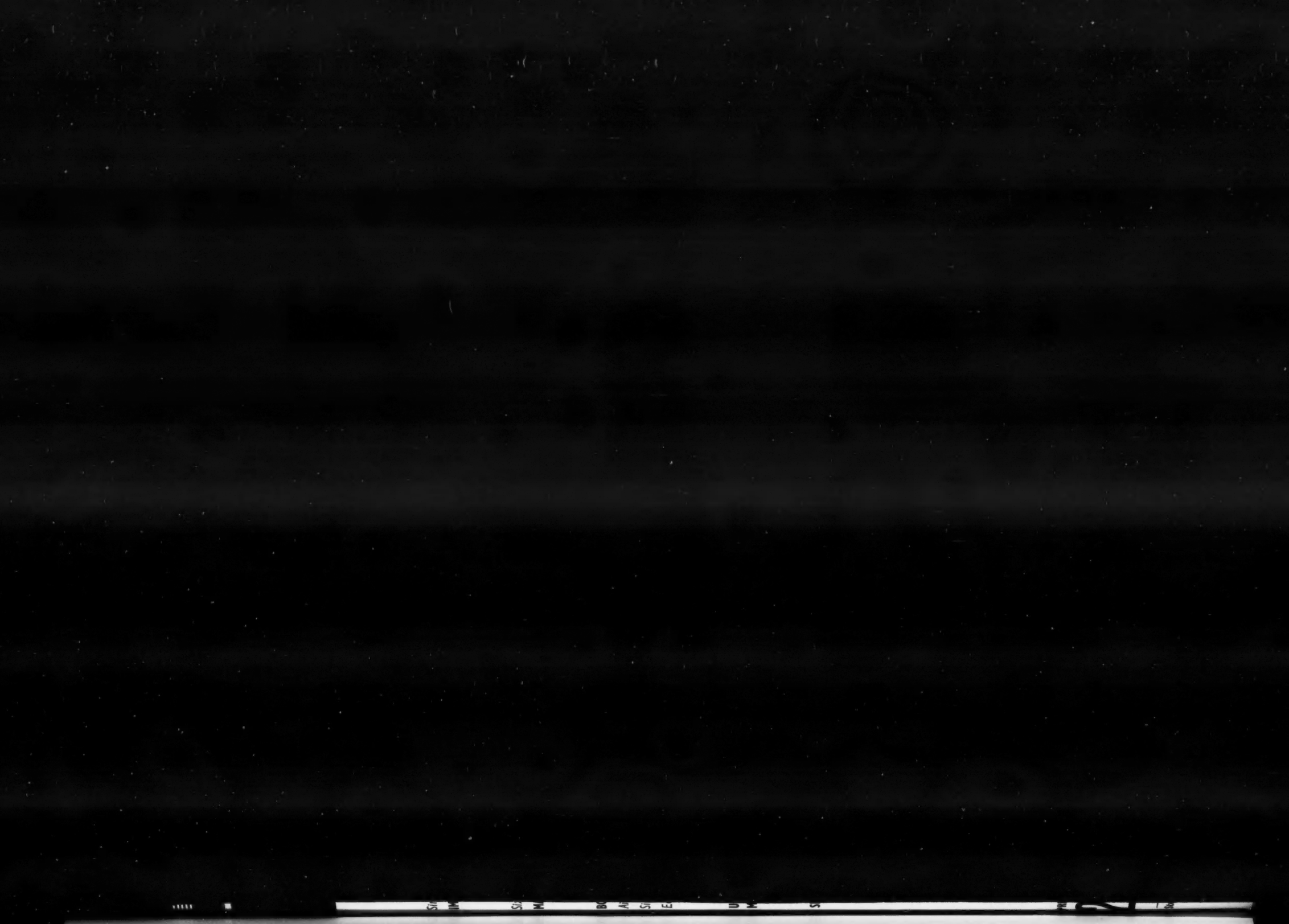
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